PB-230 512

WATER SUPPLY AND WATER QUALITY CONTROL STUDY-PASSAIC RIVER BASIN, NEW JERSEY-NEW YORK. STUDY OF NEEDS AND VALUE OF WATER STORAGE FOR MUNICIPAL, INDUSTRIAL AND QUALITY CONTROL PURPOSES

Public Health Service
New York, New York

April 1965

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY
PASSAIC RIVER BASIN
NEW JERSEY - NEW YORK

Prepared for
Department of the Army
U. S. Army Engineer District
New York, New York

PRELIMINARY
FOR REVIEW PURPOSES ONLY
NOT FOR RELEASE OR PUBLICATION

A survey has been made which discloses a future need for municipal and industrial water supplies and an immediate need for storage for streamflow regulation for the purpose of water quality control. These conclusions are based on results of economic and demographic studies. Future needs are based on projected population and an independent industrial water use survey made by the State of New Jersey.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE, REGION II
NEW YORK, NEW YORK
APRIL 1965

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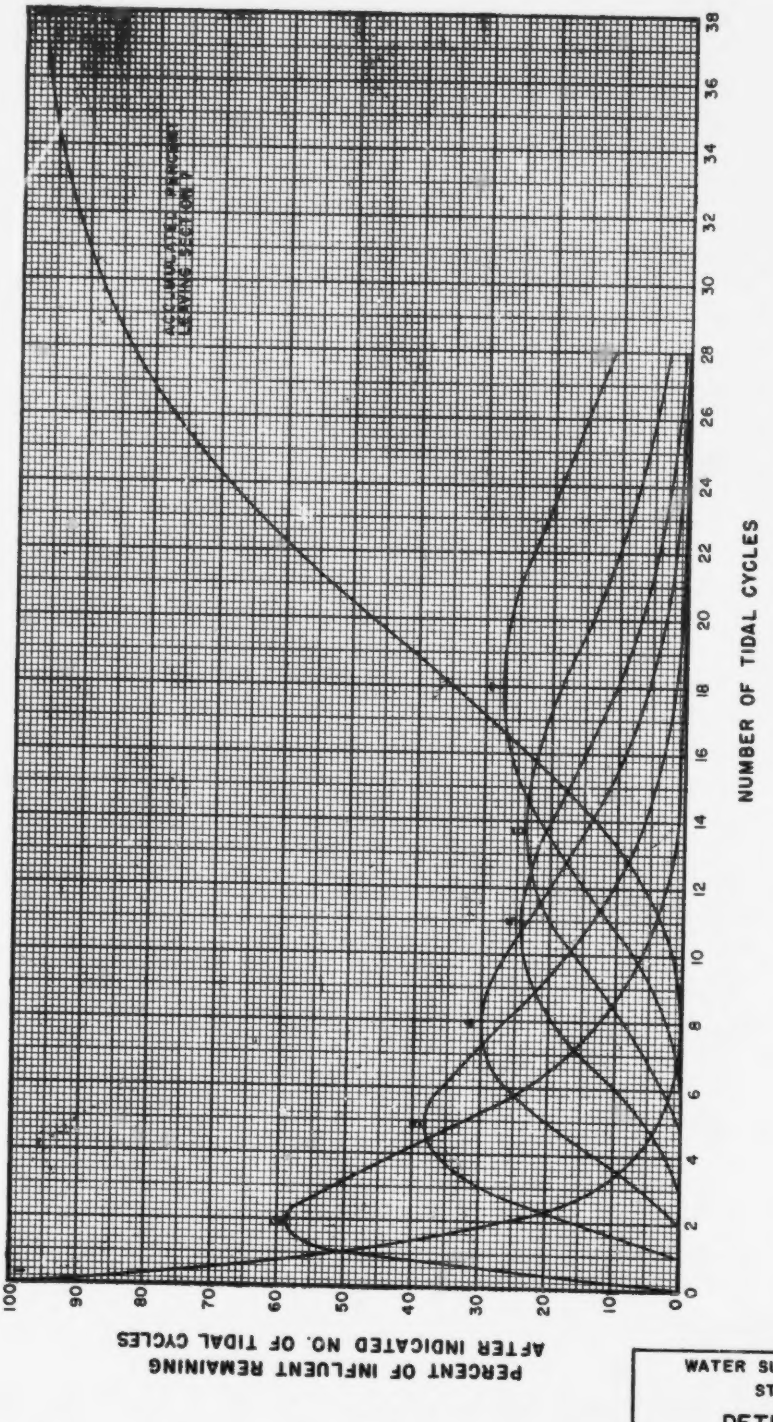

SECTION LOCATIONS

1	MILE	15.9 – 14.7
2	MILE	14.7 – 13.6
3	MILE	13.6 – 12.0
4	MILE	12.0 – 9.7
5	MILE	9.7 – 7.0
6	MILE	7.0 – 4.1
7	MILE	4.6 – 1.6

NOTE

CALCULATIONS BASED ON ONCE IN 10 YR. FLOW OF 170 CFS.

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

DETENTION TIME IN TIDAL
PORTION OF PASSAIC RIVER

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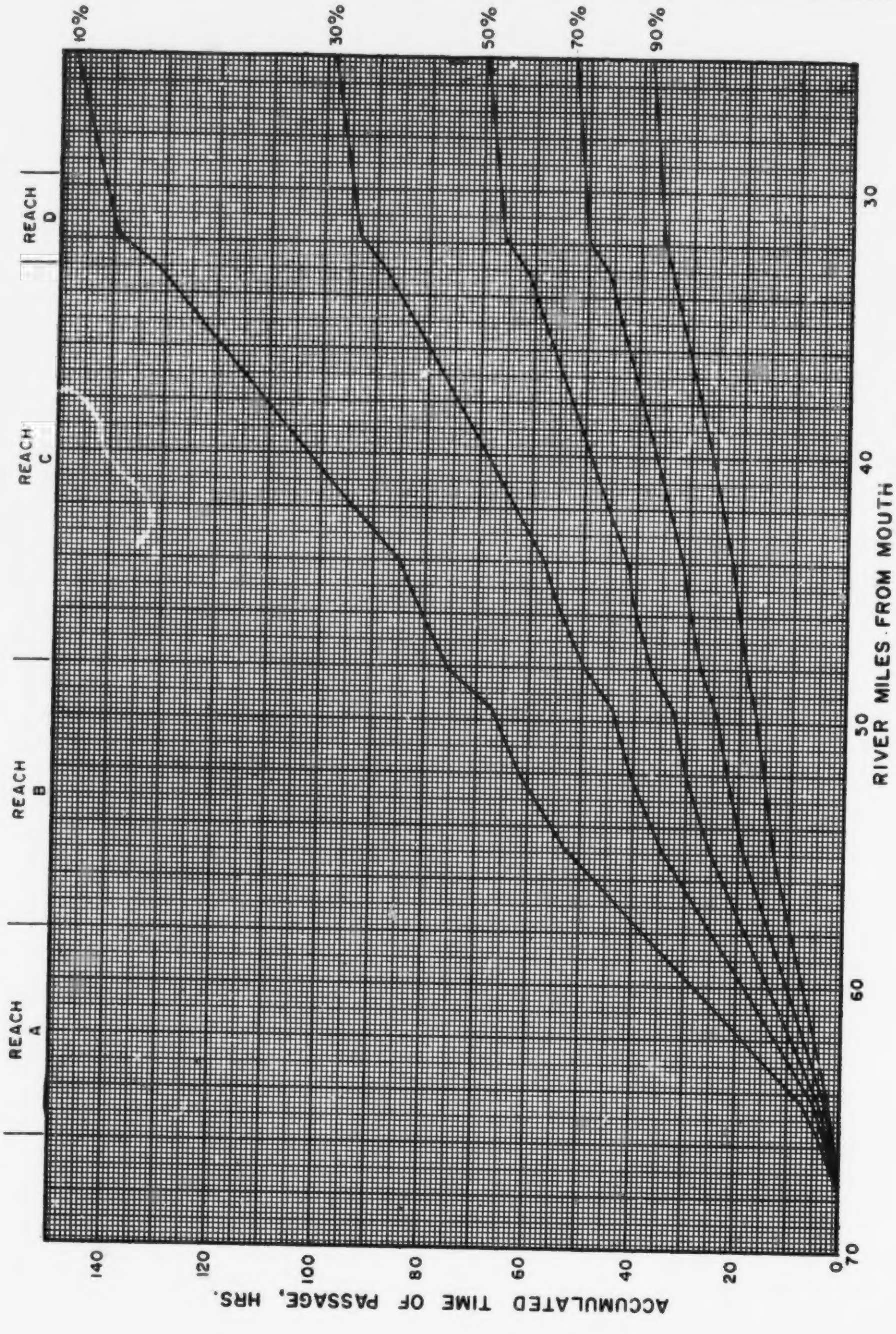
FIGURE V - 1



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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

ACCUMULATED TIME OF FLOW OF PASSAIC RIVER FOR SEVERAL PROBABILITY LEVELS

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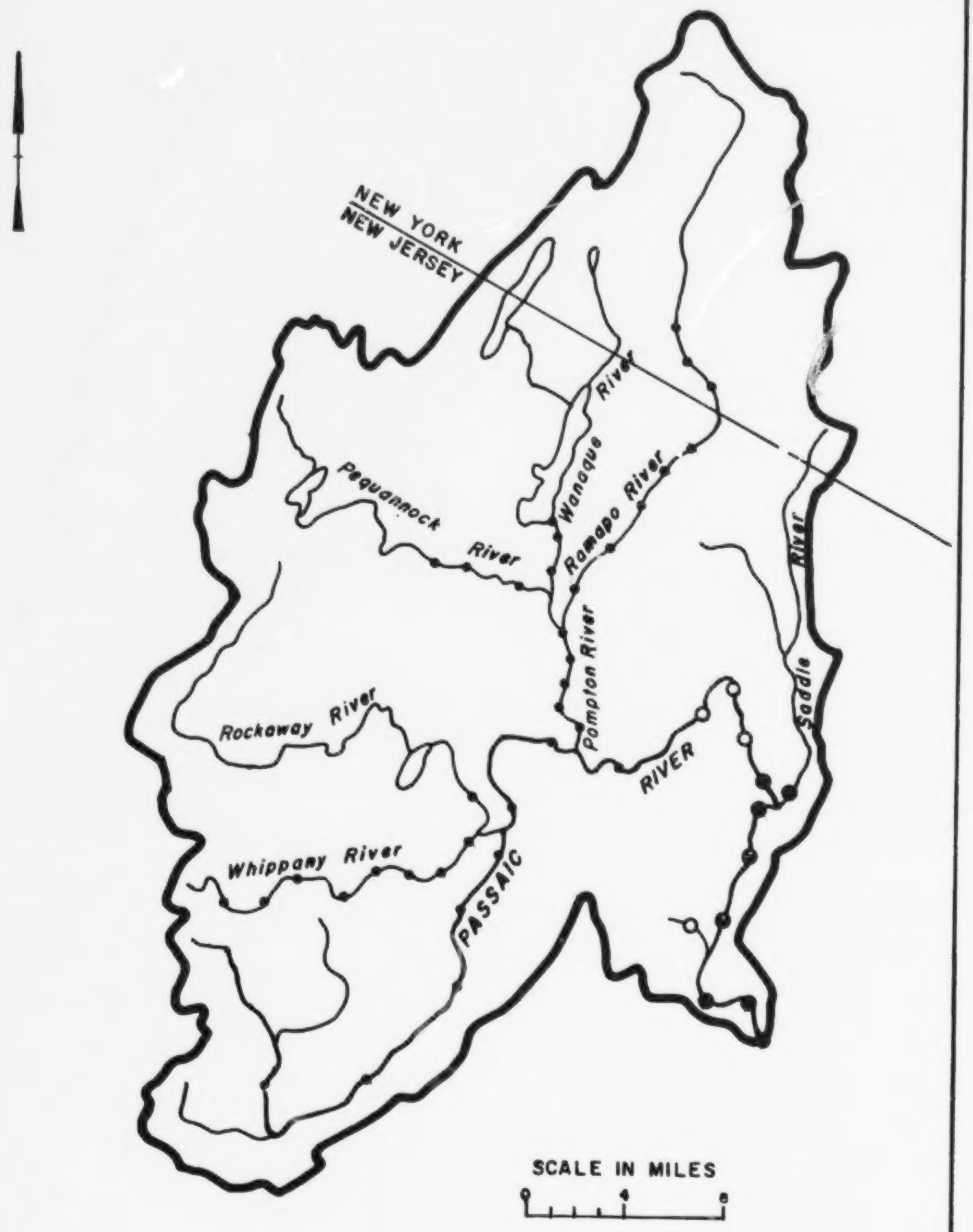
FIGURE V - 2



LEGEND

• PASSAIC VALLEY WATER COMMISSION (PVWC) STATIONS.

○ PASSAIC VALLEY SEWERAGE COMMISSION (PVSC) STATIONS.

● COMBINED PVSC AND USPHS SAMPLING STATIONS.

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY—PASSAIC RIVER BASIN

WATER QUALITY STATION LOCATIONS

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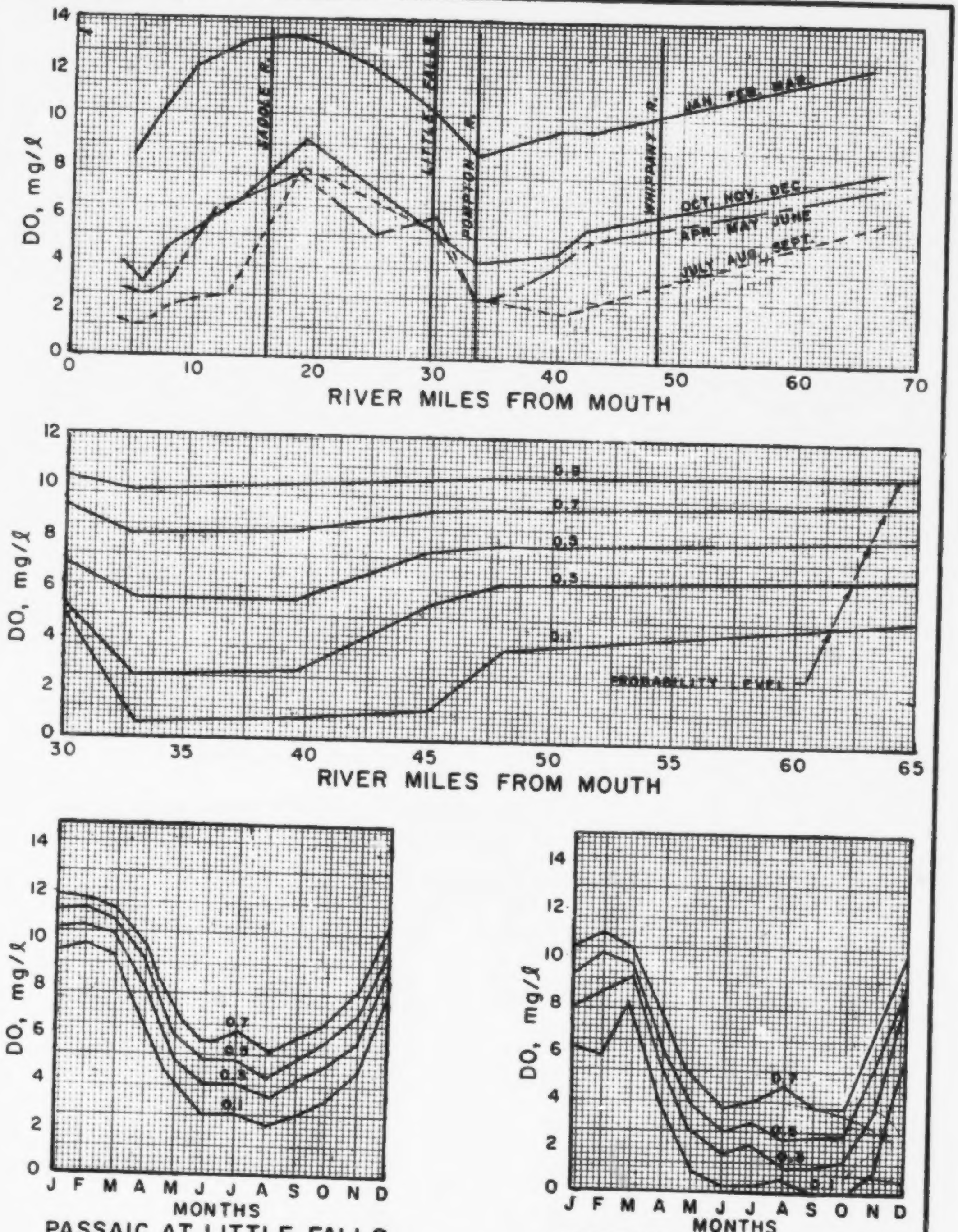
FIGURE V -3



PASSAIC AT LITTLE FALLS

PASSAIC AT TWO BRIDGES

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

SEASONAL, MONTHLY AND PROBABILITY
LEVEL DO VARIATION

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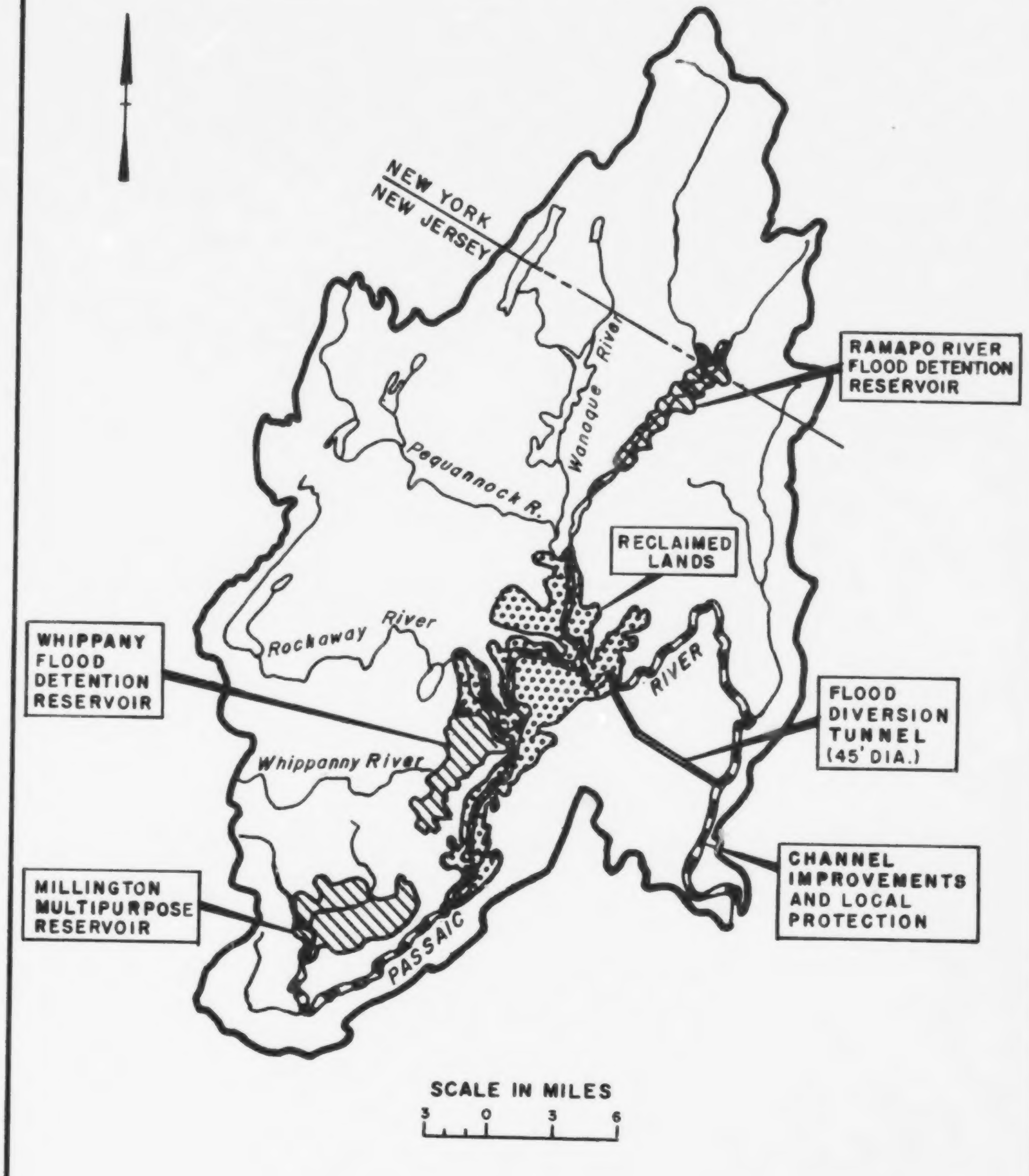
FIGURE V-4

PASSAIC RIVER, BASIN PLAN OF DEVELOPMENT


NEW YORK
NEW JERSEY
Wanaque River
Pequannock R.
Rockaway River
Whippany River
RIVER
PASSAIC
RAMAPO RIVER FLOOD DETENTION RESERVOIR
RECLAIMED LANDS
WHIPPANY FLOOD DETENTION RESERVOIR
FLOOD DIVERSION TUNNEL (45' DIA.)
CHANNEL IMPROVEMENTS AND LOCAL PROTECTION
MILLINGTON MULTIPURPOSE RESERVOIR
SCALE IN MILES
3 0 3 6

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

COMPREHENSIVE RESERVOIR TUNNEL PLAN

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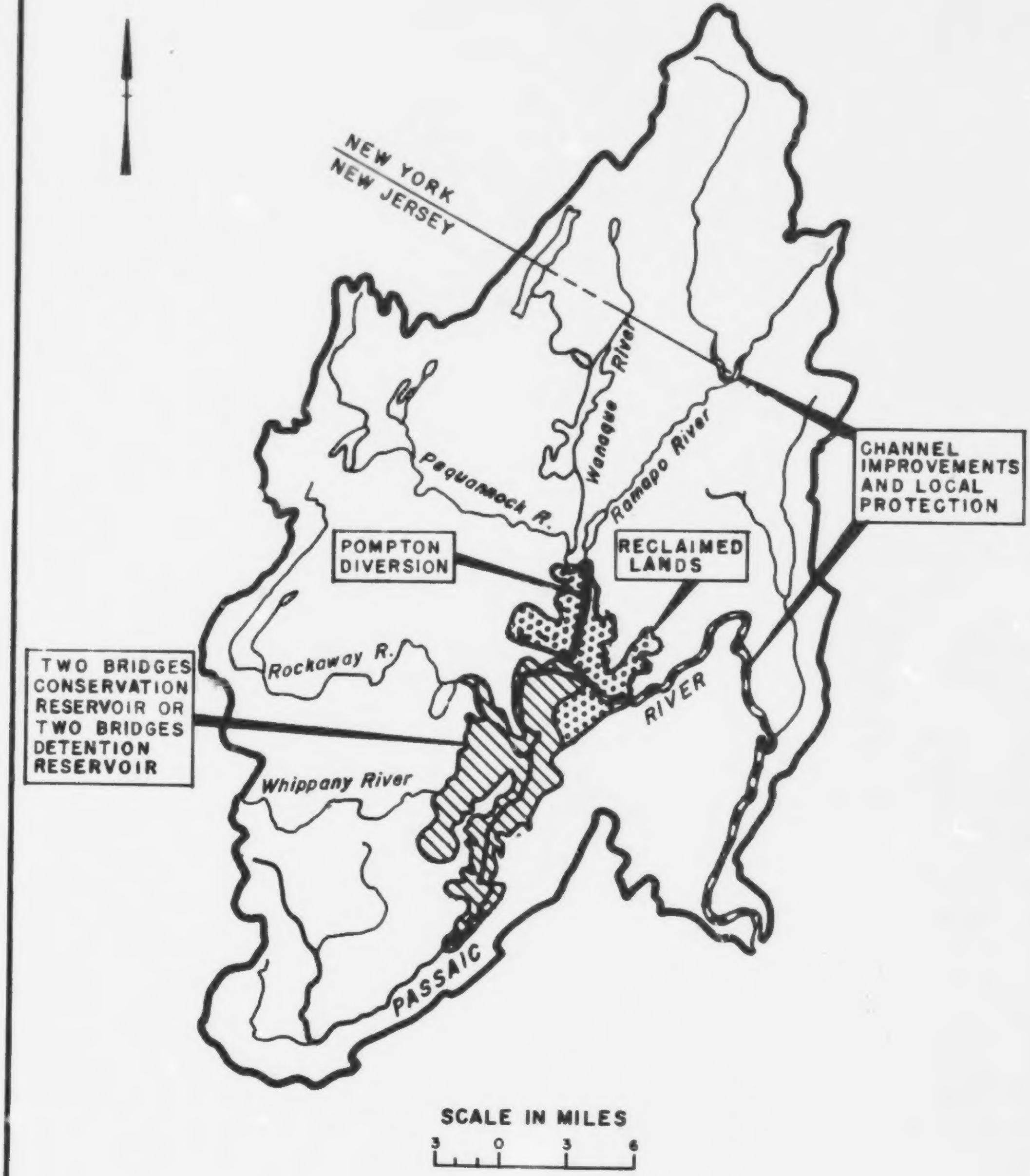
FIGURE III-1

PASSAIC RIVER, BASIN PLAN OF DEVELOPMENT



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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

CONSERVATION RESERVOIR PLAN
DETENTION RESERVOIR PLAN

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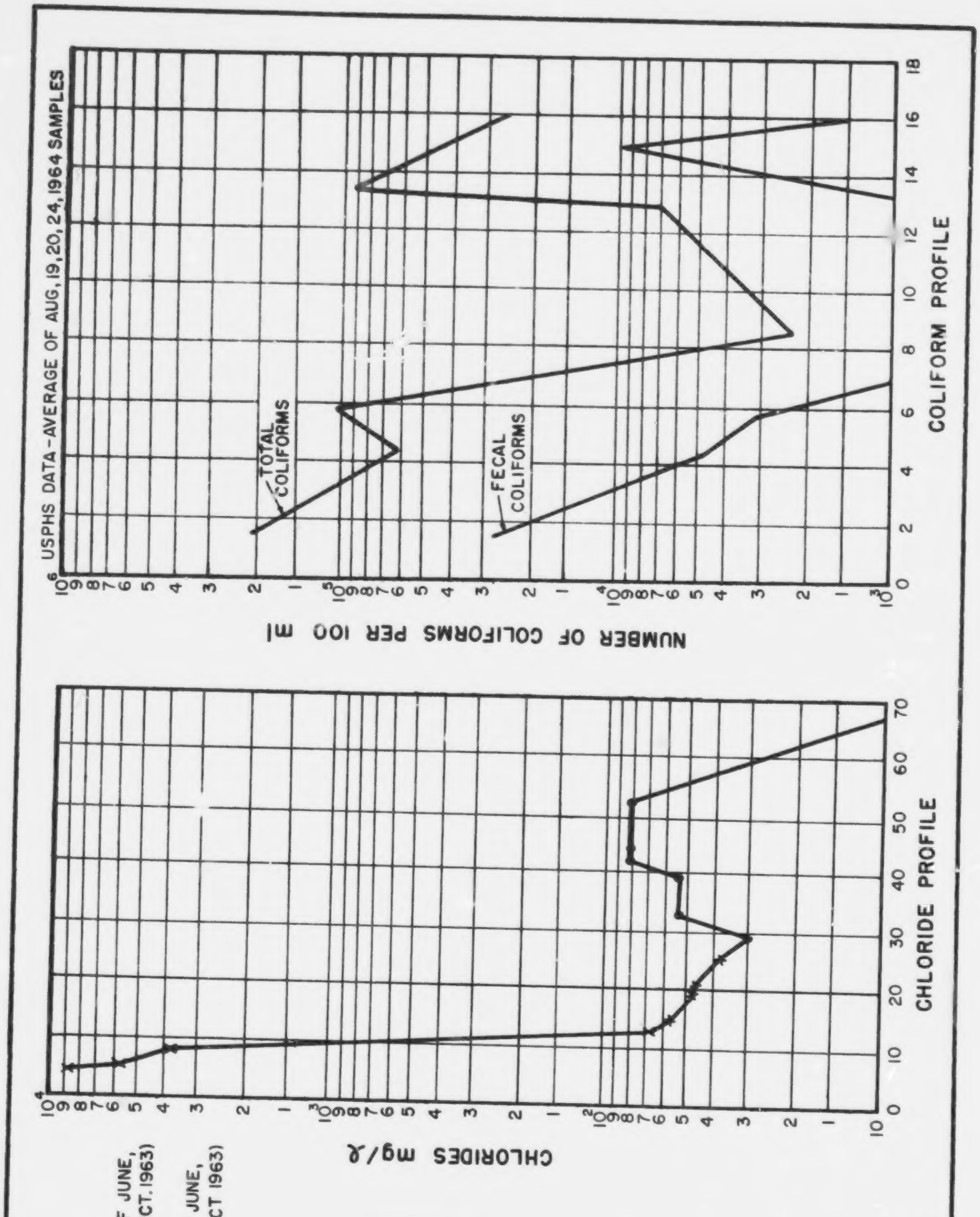
FIGURE III - 2



× PVSC DATA (AVG. OF JUNE, JULY, AUG, SEPT, OCT. 1963)

● PVWC DATA (AVG. OF JUNE, JULY, AUG, SEPT, OCT 1963)

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY — PASSAIC RIVER BASIN

WATER QUALITY
PROFILES

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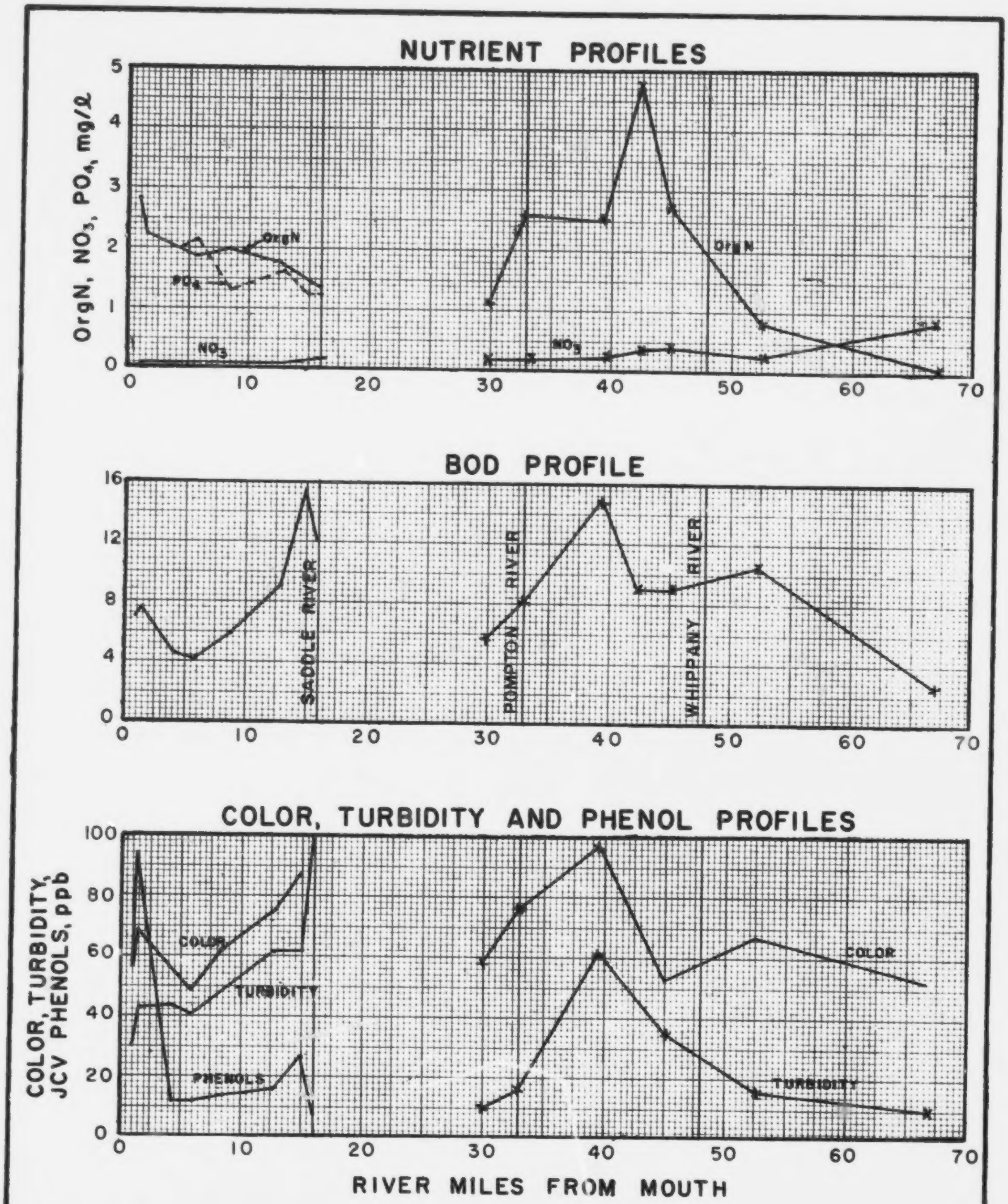
FIGURE V-5



LEGEND

- • USPHS DATA – AVERAGE OF AUG. 19,20,24, 1964 SAMPLES
- X PVWC DATA – AVERAGE OF 5 SAMPLES TAKEN JUNE, JULY, AUG, SEPT, OCT. 1963

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY — PASSAIC RIVER BASIN

PASSAIC RIVER
WATER QUALITY
PROFILES

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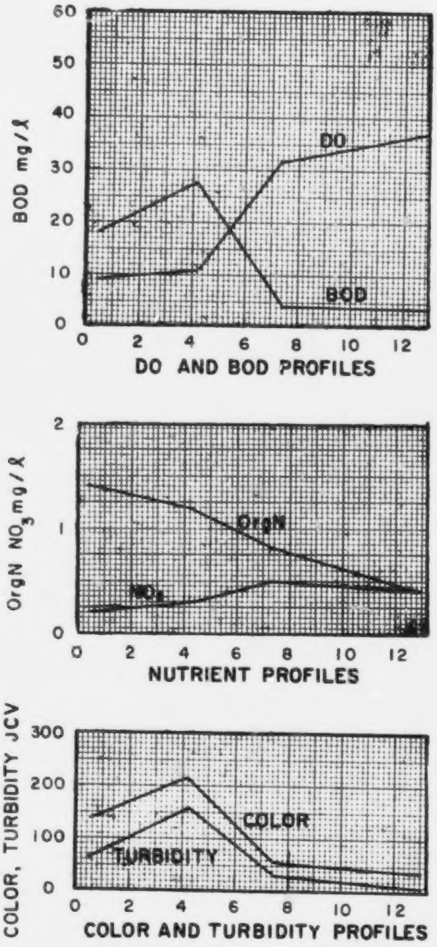
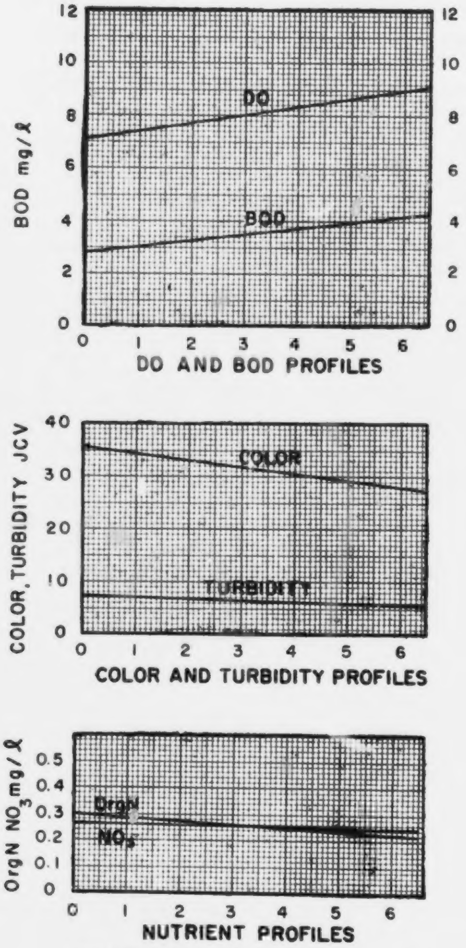
FIGURE V-6



WHIPPANY RIVER PROFILES



POMPTON RIVER PROFILES

NOTE:
ALL DATA FURNISHED BY PVWC
IS THE AVERAGE OF 5 SAMPLES
TAKEN IN JUNE, JULY, AUG, SEPT,
OCT. 1963

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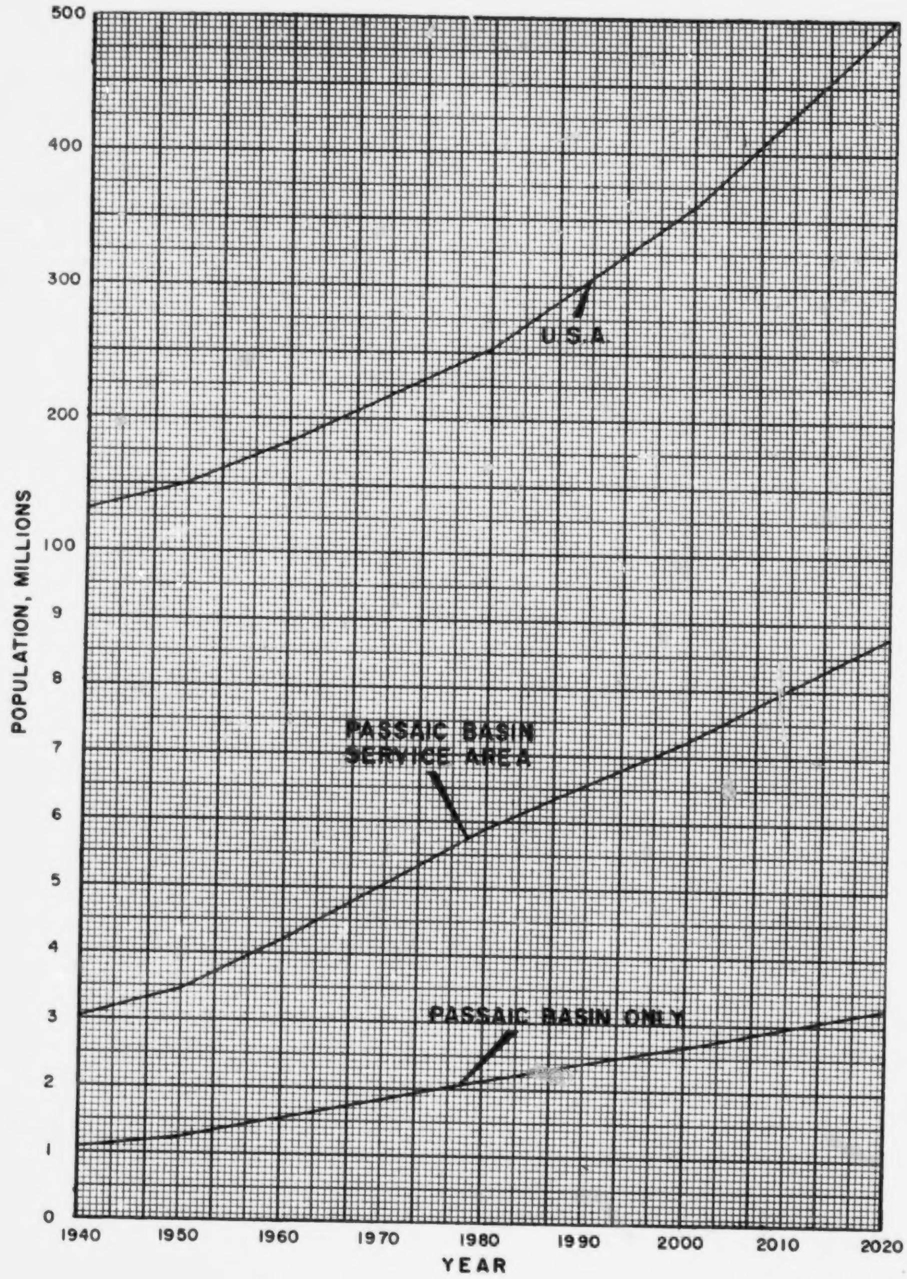
WATER SUPPLY & WATER QUALITY CONTROL
STUDY—PASSAIC RIVER BASIN

POMPTON AND WHIPPANY RIVER
WATER QUALITY
PROFILES

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
REGION II Public Health Service NEW YORK, N.Y.

FIGURE V-7



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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

POPULATION TRENDS

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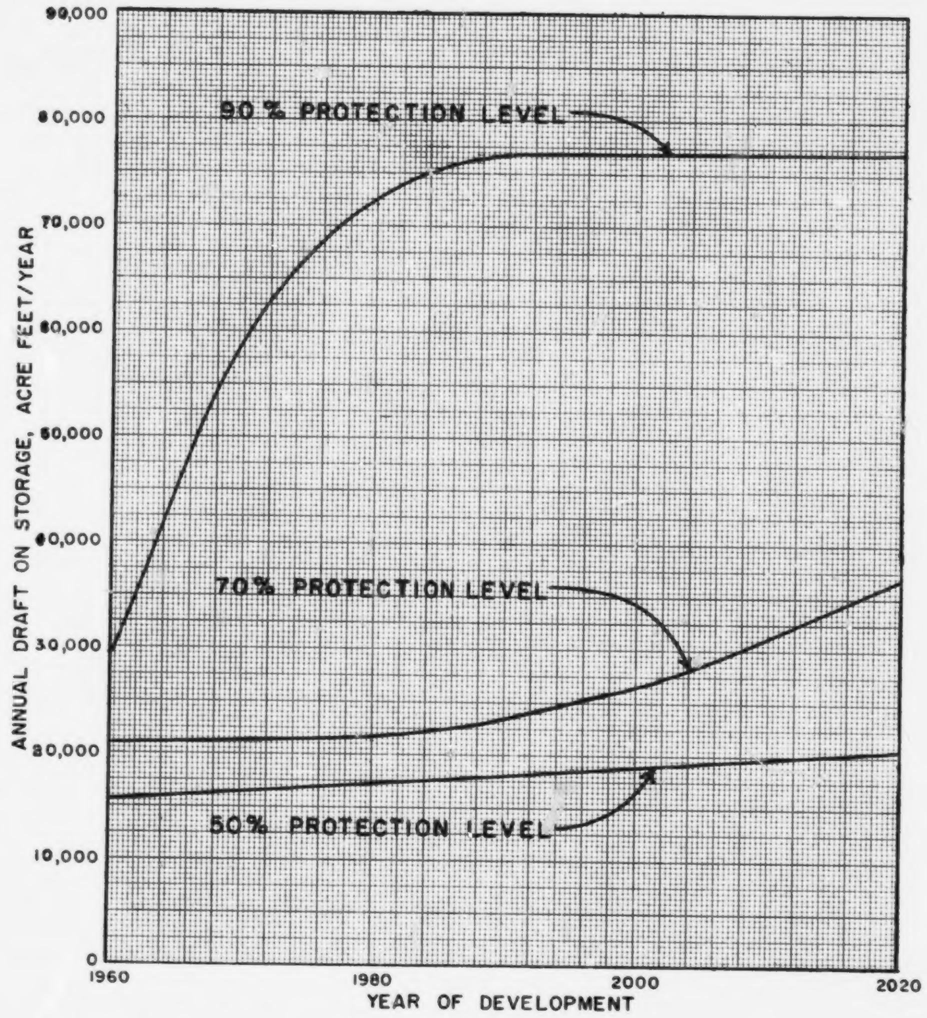
FIGURE VI-1



REQUIREMENTS FOR VARIOUS LEVELS
OF PROTECTION AT LITTLE FALLS

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

WATER QUALITY
MAINTENANCE STORAGE

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NEW YORK, N.Y.

FIGURE VII-1

EXHIBIT II

MINIMUM STANDARDS
Adopted by
The
PASSAIC VALLEY WATER COMMISSION
and approved by
The
NEW JERSEY STATE DEPARTMENT OF HEALTH
for
WASTE EFFLUENTS DISCHARGED INTO THE PASSAIC RIVER OR ITS TRIBUTARIES ABOVE THE POINT AT WHICH THE COMMISSION DIVERTS WATER FOR PUBLIC POTABLE WATER SUPPLY PURPOSES AT LITTLE FALLS, NEW JERSEY

1. The effluent shall contain no free titratable acidity or free caustic alkalinity. The pH of the effluent shall be between 5.0 and 8.3.
2. The effluent shall be free of toxic substances.
3. The effluent shall at all times be entirely free of Phenolic derivatives.
4. The effluent shall beffree of noticeable floating solids, scum, oil, grease, or sleek.
5. The effluent shall not noticeably increase the color or turbidity of the receiving waters.
6. The effluent shall be free of offensive odors.
7. The effluent shall be of such bacteriological quality that the Hoskin's most probable number of Coli-form organisms shall not exceed 240 per 100 c.c.
8. The effluent shall have a biochemical oxygen demand (B.O.D.) not exceeding at any time 40 parts per million.

All analyses and tests regarding these Minimum Standards shall be performed in accordance with the procedures contained in the latest edition of "Standard Methods for the Examination of Water and Sewage", prepared, approved and published jointly by the American Public Health Association and the American Water Works Association.

Applicable New Jersey Law: R.S. Title 58, Chapter 10, Article 1, "Pollution of Potable Waters".

EXHIBIT NO.III

Computations For Municipal and Industrial Water Supply Benefits.

1. Cost to provide 211 MGD = $38,200,000
2. Amortized at 4% for 25 yr. (bonding period) = $2,445,000
3. Present worth of 1 per period for 25 years at 3% = 42,616,350
4. Amortized at 3% for 60 years = $1,539,730
5. Estimated annual O & M costs = 1,562,100
6. Annual cost of 204 MGD from waste water reuse = $3,723,000
7. Total Annual Cost = $6,824,830
8. Year of first need 2000, discounted at 3% for 30 years = $2,811,830
9. Annual cost of applying copper sulfate to reduce algae and taste and odor problems for two treatments per year at $1.25/acre per treatment for 13,900 acre reservoir = $34,750/year
10. Net annual value of Municipal and Industrial Water Supply Benefits = $2,846,580

EXHIBIT NO. IV

Storage For Water Quality Control Benefit Calculations:

A. Estimated Annual Value of Recommended Storage

1. Estimated Construction Cost of a single purpose reservoir to provide 77,000 acre-ft/year of usable storage plus 15,000 acre-ft/year contingency for evaporation and dead storage \$128/AF X 92,000 AF = \$11,750,000

2. Year of first need = 1960

3. Construction cost amortized for 100 years at a 3 percent interest rate = 372,000

4. Estimated annual operation and maintenance costs @ 5 percent of construction costs = \$18,600

5. Total Annual Costs = \$390,600

B. Estimated Annual Value of Reservoir - Tunnel Plan

1. Assume rate of change of protection level with benefits is directly proportional to protection level or $dP/dB = -KP$ where P=(1 - Protection Level Ratio), B=dollar value of benefits times 10^5 and K=rate constant

2. For $B_1 = \$0$, $P_1 = (d-0.1)=0.9$ and the equation $P = 0.9e^{-0.563B}$ results

3. Reservoir protection level = 0.73 (P-0.27) and B=2.14 or \$214,000/year

C. Estimated Annual Value of Comprehensive Reservoir Plan

1. Annual benefits from water quality improvements = \$390,600/year

2. Negative value to apply algicides (See Exhibit III) = \$34,750/year

3. Net annual benefit = \$355,850

Name PASSAIC RIVER	River Mile	Use	Population Served In Thousands	Flow MGD	Treatment
Rochelle Park	Sa 3.4	SD	2.6	0.30	S,Cl
Peckman River					
Little Falls Twp	P 28.2 Pec 2.2	SD	5.5	0.6	TF,Cl
Verona Boro	Pec 5.0	SD	11	1.2	TF,Cl
Essex County Institution District	Pec 3.8	SD	3.9	0.5	TF,Cl
Cedar Grove Twp	Pec 2.2	SD	18	1.8	TF,Cl
Singac Brook					
Donahue's Restaurant	P 31.9 S 0.8	SD	-	.01	S,SF,Cl
Wayne Township	P 31.9 S 2.2	SD	-	0.5	AS,Cl
Chemway Corp.	P 31.9 S 3.5	SD	-	0.1	AS,Cl
Deepavaal Brook					
Curtiss-Wright Corp.	P 32.2 D 1.0	SD	2.5	0.07	TF,SF,Cl
Curtiss-Wright Corp.	P 32.2 D 1.1	SD	-	0.7	Oil Sep-Cooling Water only
Curtiss-Wright Corp.	P 32.2 D 1.2	SD	0.3	0.005	SF,Cl
Pompton River					
Packanack Brook	P 33.0 Po 1.5	Tributary			
Ramapo River	P 33.0 Po 6.6	Tributary			
Pequannock River	P 33.0 Po 6.6	Tributary			
Packanack Brook					
Wayne Township	P 33.0 Po 1.5 Pa 1.5	SD	-	0.8	TF,Cl

Name PASSAIC RIVER	River Mile	Use	Population Served In Thousands	Flow MGD	Treatment
		Ramapo River			
Dupont Cap Works	P 33.0 Po 6.6 Ra 2.6	SD	-	.03	SF,Cl
Ford Motor Car Co. Domestic Wastes	Ra 14.1	SD	5	0.1	TF,Cl
Ford Motor Car Co. Industrial Wastes	Ra 14.1	SD	-	0.8	C,L,Cl
American Brake Shoe Co.	Ra 14.5	SD	0.2	0.015	SF,Cl
Suffern Village	Ra 14.9	SD	5	0.55	TF,Cl
Avon Products, Inc Industrial Wastes	Ra 15.0	SD	-	0.002	Special Process
Motel on the Mountain	Ra 15.8	SD	-	0.005	TF, Cl
Town of Tuxedo Park	Ra 21.3	SD	2	0.04	TF,Cl
Village of Tuxedo Park	Ra 24.7	SD	0.9	0.07	TF,Cl
Sterling Forest Gardens	Ra 25.1	SD	-	0.05	AS,Cl
Sterling Forest Corporation	Ra 25.1	SD	-	0.05	AS,Cl
		Pequannock River			
North Jersey District Water Supply Commission	P 33.0 Po 6.6 Pe 1.9 Wa 5.1	MWS	750	99.0	Cl
Butler-Bloomingdale	P 33.0 Po 6.6 Pe 4.4	SD	7	1.0	SF,Cl
Macopin Intake	P 33.0 Po 6.6 Pe 10.4	MWS	219	58	Cl

20<

Name PASSAIC RIVER	River Mile	Use	Population Served In Thousands	Flow MGD	Treatment
		Whippany River			
Rockaway River	P 45.8 W 1.2	Tributary			
Hanover Township	W 3.9	SD	6	0.6	TF,Cl
Black Brook	W 4.6	Tributary			
Sandoz, Inc.	W 4.6	SD	-	0.06	SF,Cl
Bell Laboratories	W 5.8	SD	-	.065	AS,SF,Cl
Rowe Mfg. Co.	W 6.0	CW	-	0.14	-
Malapardis Brook	W 6.5	Tributary			
Whippany Paperboard Mfg. Co., Inc.	W 6.9	SD	-	8.5E	C,S,Cl
Whippany Paperboard Co., Inc.	W 7.0	IWS	-	9.0	NONE
Allied Chemical Co.	W 7.4	SD	-	-	Discharge Cooling Water Only
U. S. Radium Co.	W 7.4	SD	-	.01	Discharge Cooling Water Only
Rayonier Co.	W 8.2	SD	-	.05	TF,Cl
Flintcote Co. Plant	W 9.2	SD	-	.01	S,SF,Cl
Flintcote Co. Lab.	W 9.2	SD	-	.001	S,SF,Cl
Morristown	W 9.4	SD	17	1.5	AS,Cl
Lake Pocahontas	W 11.9	RP	-	-	-
Speedwell Park	W 12.7	RP	-	-	-
Greystone Park State Hospital	W 13.3	SD	6	1.5	TF,Cl
Shonghum Mountain Sanitorium	W 15.6	SD	-	.03	TF,Cl

Name	River Mile	Use	Population Served In Thousands	Flow MGD	Treatment
PASSAIC RIVER					
Sunrise Lake	W 17.0	RP	-	-	-
Rockaway River					
Rockaway Valley STP	P 45.8 W 1.2 Ro 7.4	SD	45	5.0	TF,Cl
Boonton Reservoir	Ro 8.0	MWS	500	60.0	Cl
Black Brook					
Esso Research Laboratory	P 45.8 Ro 1.2 W 3.9 B 2.4	SD	-	0.04	TF,SF,Cl
St. Elizabeth College	B 2.5	SD	-	0.15	S,SF,Cl
Canoe Brook					
Commonwealth Water Co.	P 56.0 C 1.0	MWS	195	17	C,S,RSF,Cl
Dead River					
Lyons Veterans Hospital	P 70.5 De 4.2	SD	3.6	0.4	TF,SF,Cl

by users in the tidal portion.

Intangible benefits from this plan will occur from improved water quality in the reach from Millington to the upper tidal portion below Dundee Dam. The major benefits and locations are described below:

1. Aesthetic improvements by the elimination of odorous and septic conditions in the Passaic River below the confluence with the Whippany and Rockaway Rivers to Two Bridges, a distance of approximately 15 miles. However, conditions will not be improved to the extent of permitting swimming. The dissolved oxygen concentration will fall below 5.0 mg/l more often than the 90 percent protection level provided for at Little Falls, which may also inhibit development of the reach for fishing.

2. Improvement of the Passaic River below Two Bridges to its confluence with the Saddle River such that the area may be utilized for fishing, swimming, and other allied recreational purposes, in addition to its improved aesthetic appearance and value.

Central Basin Reservoir - Partial Development Plan

This plan of development will have tangible economic benefits as a result of improved water quality through storage and low flow augmentation.

The greatest improvements and hence, greatest benefit, will occur in the reach below Two Bridges extending to the tidal portion below the confluence of the Saddle River. No improvement or change in water quality will occur in the reach of the Passaic River from Millington to Two Bridges, and the section of the Passaic River below the confluence of the Whippany and Rockaway to Two Bridges will continue to be a poor quality water with persistent and frequent septic conditions by the year 2020.

The Passaic Valley Water Commission will benefit substantially from improved water quality as mentioned previously.

Industrial water users below Two Bridges will also benefit substantially as mentioned previously.

Intangible benefits will occur from improved water quality below Two Bridges. This reach, as in the Comprehensive Reservoir Plan, will be improved to the extent that it may be developed for recreation, fishing and boating and have increased aesthetic value.

Central Basin Reservoir - Full Development

This plan of development will result in tangible and intangible benefits both positively and negatively. By positive benefits, it is meant that there is an increase in dollar value while negative benefits would imply a decrease in dollar value.

Positive tangible benefits would occur in the downstream portion of the reservoir through improved water quality and in the reach of the Passaic River from Two Bridges to the confluence of the Saddle River, a distance of 18 miles. Specifically these benefits would result from an improvement in the dissolved oxygen concentration, reduction in hardness, total solids, biochemical and chemical oxygen demands and a reduction in chlorides due to the advective force of greater flows on the tide in the salt water portion. This would make available in the lower portion of the river more waters for municipal or industrial uses requiring low chloride concentrations.

Intangible benefits would arise from the aesthetic improvements in water quality in the areas described above.

Negative tangible benefits resulting from the construction of the reservoir are expected to occur primarily from a decrease in water quality throughout the reservoir and in the reach of the Passaic River below the reservoir to tidewater by increasing the taste, odor and possibly color of the reservoir water. These degradations of quality will require extensive treatment in addition to present processes used to produce a palatable water supply and satisfactory industrial process water. An alternative to extensive treatment would be the application of algicides to the reservoir for control of eutrophication. Additional degradation is also possible from contamination by the sanitary landfill of toxic and potentially dangerous chemicals.

Negative intangible benefits will occur in the upper portion of the reservoir in the vicinity of the mouth of the Whippany and Rockaway River arising from possible odorous and unpleasant conditions when the reservoir level is low. The heavy BOD load from the Whippany-Rockaway River would be concentrated in the area of their mouths giving rise to this condition. Property values, recreational uses, fish and wildlife propagation would all be seriously impeded in this area of the reservoir.

Central Basin Reservoir - Dry Detention Plan

There will be no tangible or intangible benefits associated with this plan of development as a result of improved water quality since there will be no change in existing quality.

Value of Benefits For Water Quality Control

Because of limitations previously discussed, the value of the storage recommended and provided by the proposed projects has been evaluated on the basis of providing single purpose reservoirs at the proposed reservoir sites. On this basis, the annual value of the storage recommended, 77,000 acre-feet/year plus evaporation and dead storage losses of 15,000 acre-feet/year, was computed to be $390,600.

The annual value of the storage provided by the proposed reservoirs was computed on the basis of level of protection provided as compared to level of protection recommended, and by assuming that the rate of change of the protection level with benefits was directly proportioned to the protection level. For details see Exhibit No. IV.

The annual value of water quality control storage provided by the Reservoir Tunnel Plan (all three modifications) would be $214,000, assuming the entire 37,650 acre-feet is used for quality control purposes.

The annual value for water quality control storage provided by the Conservation Plan would be $355,850, on the basis that, although no storage releases are required, it would still provide the same level of protection as a reservoir constructed to provide 77,000 acre-feet of storage for quality control purposes. The value of benefits has been reduced, though, to reflect the additional cost of applying algicides in the form of copper sulfate to the reservoir. This cost was computed on the basis of $1.00/acre for chemical costs, $0.25/acre for distribution costs and two applications per year.(5)

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of the Passaic River between the Whippany-Rockaway Confluence and Two Bridges and are not suitable for quality control purposes.

The Comprehensive Plan reservoir controls and stores for some length of time all waters above Little Falls. It is, therefore, felt that storage for water quality control purposes is not feasible for this reservoir and probably will not be necessary due to the natural stabilization of organic wastes that storage within a reservoir provides. It is felt, though, that eutrophication of this reservoir will occur and that in order to control this problem algicides will be used in lieu of additional water. A more detailed analysis of this reservoir is required to completely evaluate this condition.

IX. BENEFITS

Value of Water Supply Storage

A total water supply demand of 1,930 MGD is predicted by the year 2020 which will leave a net deficit of approximately 615 MGD. If state and private development occurs as planned, the deficit would be reduced to 415 MGD. In order to supply this deficit, the following alternate sources of supply were considered:

(1) Single purpose reservoir at Millington supplemented by salt water conversion or waste water reuse.

(2) Single purpose reservoirs at Millington and Two Bridges supplemented by salt water conversion or waste water reuse.

(3) Single purpose reservoir at Two Bridges supplemented by salt water conversion or waste water reuse.

(4) Salt water conversion or waste water reuse entirely.

It was assumed that if adequate waste water were available, the reuse of this source would be the most economical as based on 1963 figures for treatment only of 35 cents/1000 gallons for waste water reuse by freezing and 50 cents/1000 gallons for salt water conversion by freezing.(13) The 1962 flows from the Bergen County Sewage Authority plant, Passaic Valley Sewerage Commissioners plant, and the Essex-Union County Joint Meeting plant total 263 MGD. Projecting these figures to the year 2020, a total of 550 MGD of waste-water is available and is adequate to meet the projected water demands.

The single purpose reservoir at Two Bridges, which will supply a dependable yield of 211 MGD, supplemented by 204 MGD from waste water reuse was determined to be the least cost alternate. The annual value of this alternate was computed on the basis of providing complete treatment of the 211 MGD developed and application of an algicide to the reservoir to control taste and odor problems. A value of $0.50/1000 gallons of delivered water was assumed for the waste-water reuse. Application of the algicide was assumed to cost $2.50/acre for two applications per year.(5) The cost of water treatment facilities was assumed at $100,000/MGD of capacity with operation costs at $20/MG of treated water.(10) Senate Select Committee Print No. 32 cost of construction figures were used to estimate the cost of a single purpose reservoir.

The annual value of the required 415 MGD of water supply storage by 2020 was computed to be $2,846,580 by this method. For details see Exhibit No. III.

General Need for Improved Quality

The provision of adequate water quality in the Passaic River will provide many benefits, intangible and tangible. Intangible benefits are those which have real value, but are not fully measurable in monetary terms. These include such things as the elimination of health hazards, improvement in welfare and the enjoyment of unpolluted waters.

Tangible benefits are those which have an actual measurable dollar value. Common tangible benefits include reduction in the costs of treating domestic and industrial water, reduction in maintenance costs, and fixed or recreational opportunities.

Present water quality conditions in the Passaic River requires flow augmentation in order to restore and maintain beneficial water uses. Low flow conditions now result in many complaints of odorous conditions along the Passaic River in the vicinity of the Whippany-Rockaway confluence, in decreased production of large industrial firms above Little Falls, in near complete destruction of the river above and below Little Falls for fishing, and a decrease in the recreational value of the river during the summer months. The lower portion of the Passaic River, below Dundee Dam is considerably degraded at present with high phenol concentrations, chloride, coliform bacteria, biochemical and chemical oxygen demand and low dissolved oxygen concentrations during the summer months. These factors make this portion of the river unsuitable without extensive treatment for any purposes other than for power supply, cooling water, navigation and as a wastes carrier.

It should be noted here that the conditions described above exist not entirely because of inadequate wastes treatment practices, as all wastes within the basin are reported to receive either the equivalent of secondary treatment or greater or are carried outside the basin, but primarily because the assimilative capacity or allowable ratio of treated wastes to river water has been exceeded. When this situation prevails, the only solution is removal of wastes from the system by carriage outside the basin, tertiary treatment, or to increase the river's assimilative capacity by increasing the stream flow during critical periods.

Without streamflow regulation it is estimated that the waste loads projected for the year 2020 will result in average monthly dissolved oxygen concentrations of less than 4.0 mg/l six months of the year 50 percent of the time in the Passaic River just above its confluence with the Pompton River; and an average monthly dissolved oxygen level of less than 4.0 mg/l six months of the year 30 percent of the time at Little Falls, N. J.

Following is an itemization of intangible and tangible benefits associated with each proposed plan of development delineating each beneficiary or the beneficial use being protected:

Comprehensive Reservoir - 1962 Tunnel Plan

This plan of development will result in tangible economic benefits as follows:

1. Reduction in mosquito control and extermination costs.

2. Improved water quality from better flow conditions, dilution, and flow augmentation of good quality water.

The greatest improvement and hence greatest benefit will occur in the reach along the Passaic River from Millington to Little Falls. The beneficial effects will diminish downstream as the percentage of dilution decreases as a result of incoming tributary flow. However, benefits will accrue as far downstream as the upper tidal portion below Dundee Dam.

Mosquito Control

The Corps of Engineers project will reclaim much of the central basin swamp and meadowlands through the deepening of the Passaic, Rockaway, Whippany and Pompton Rivers. More specifically, the areas for potential reclamation are as follows: Essex County, 7,920 acres; Morris County, 12,890 acres; Passaic County, 2,780 acres; and Union County, 50 acres. It is anticipated that the drainage of these swamp and meadow lands will materially reduce the mosquito control problem in the Passaic Valley and result in widespread general benefits along the Passaic River and its tributaries.

Improved Water Quality

Municipal water supplies taken from the Passaic River would benefit from improved water quality primarily through a reduction in treatment and operation costs. The two major withdrawals of water for municipal supplies are by the Commonwealth Water Company, located in Chatham along the upper Passaic River and the Passaic Valley Water Commission located at Little Falls.

The Commonwealth Water Company holds diversion rights to 11.0 MGD only for flows above 75 MGD (measured at Chatham)--except during the four summer months--and improvements in water quality will have minimal effects because currently conditions are generally satisfactory when flows exceed 75 MGD at Chatham. The Passaic Valley Water Commission, however, would benefit substantially from the improved quality and additional flow available for water supply use during an emergency or extreme drought. The effects would be such that savings in chemicals and in-service operating time of the rapid sand filters could be realized. Also, there would be some reduction in maintenance, manpower and power costs.

In general, an improvement in water quality and increase in dry weather flow through flow augmentation will benefit industrial water users as follows:

1. Reduction in costs by minimizing production cutbacks from lack of water or reducing the quantity of higher cost water obtained from other sources.

2. Improved water quality can affect the product by reducing or eliminating the decay caused by biological action, staining or discoloration.

3. Improved water quality can reduce the corrosion, scale deposits, and deterioration of plant equipment with subsequent savings in capital and maintenance costs.

4. Increased low flows and improved quality can increase plant efficiency by eliminating tuberculation, foaming, high temperature, power costs, and water treatment costs.

Based upon information secured from industrial water users along the Passaic River, it was determined that substantial savings will accrue as a result of improved quality. While the benefits are widespread, it should be noted that 30 MGD of industrial water is withdrawn from the Passaic River between Beatties Dam and tidewater and approximately 250 MGD for cooling water purposes in the tidal portion. Little or no benefit will be realized

North and South Branches of the Raritan River and is filled by pumped diversion of flood waters of the South Branch. Spruce Run reservoir impounds natural runoff from two tributaries of the South Branch. Also, because of a lack of data concerning the quantity of water industry supplies themselves, it was assumedtthat the 1960 industrial self-supplied demand of 315 MGD is the dependable yield of this source. While this assumption is most likely conservative, it is felt that it is within the scope of accuracy required by this report. The total developed dependable yield of water supply systems in the service area is then 1,305 MGD.

Table VII-5 shows the total water demand projections and deficits to the year 2020. A deficit of 280 MGD will occur in 2000 and increase to 625 MGD by 2020. Following is a list of additional water supply sources that have been considered:

1. Ramapo River development of 5 MGD by either on-river storage at the Oakland Detention Reservoir site or by diversion for storage in off-channel reservoirs.

2. Pumped diversion of 10 MGD from the Saddle River to Oradell Reservoir via Musquapsink Creek to supplement the Hackensack Water Company yield.

3. Morris County development of reservoir sites on the Passaic, Whippany and Rockaway Rivers will provide an estimated 20 MGD.

4. The New Jersey Department of Conservation and Economic Development (NJDCED) reports that development of the Millstone River by a reservoir on Six Mile Run will yield 10 MGD from the storage of surface run-off and increase the yield of the Delaware-Raritan Canal, which is currently limited by lack of storage, by 30 MGD.

5. Preliminary studies by NJDCED of the North Branch of the Raritan River indicate that development of this source is limited to approximately

TABLE VII - 5

Total Water Demand Projections and Deficits, MGD*

Year	Municipal Demand	Industrial Self Supply	Total	Deficit
1960	540	315	855	0
1980	840	430	1270	0
2000	1075	510	1585	280
2020	1365	565	1930	625

* Figures based on a developed dependable yield of 1305 MGD.

80 MGD by lack of suitable storage sites. This yield may be increased, however, by consideration of off channel storage or pumped diversion to the Great Swamp Reservoir on the upper Passaic River near Millington.

6. While groundwater resources have generally been extensively developed within the service area and are not expected to contribute significantly to future water needs, the Morris County Planning Board in a report titled, "Future Water Supply Requirements for Morris County, April 1956" estimated a present dependable groundwater yield of 100 MGD. This would then provide an additional 35 MGD over the present 65 MGD groundwater withdrawals within Morris County.

7. Possible development of groundwater storage in the Pennsauken formation in the upper Millstone Basin east of Princeton may yield up to 20 MGD.

Table VII-6 summarizes the state and privately planned development of water resources within the Passaic River Basin service area. A total addition of 210 MGD is currently planned. This quantity, however, would still leave deficits of approximately 70 MGD and 415 MGD by the year 2000 and 2020 respectively.

The U. S. Army Corps of Engineers proposals for development in the Passaic River Basin as described previously would provide the following water supply dependable safe yields readily available to users within the basin:

TABLE VII - 6

FUTURE WATER RESOURCE DEVELOPMENT WITHIN THE PASSAIC RIVER BASIN SERVICE AREA

PROJECT		DEPENDABLE YIELD MG
Ramapo River Development		5
Saddle River Diversion		10
Morris County Reservoirs		20
Millstone River Development Surface Run off		10
Increased yield of Delaware Raritan Canal		30
North Branch of the Raritan Development		80
Morris County Groundwater		35
Pennsauken Groundwater Storage		20
	Total	210

1. Comprehensive Reservoir-Tunnel Plan	
a. 1962 Alternative	41 MGD
b. Detention Reservoir at Two Bridges Modification	41 MGD
c. Conservation Pool at Two Bridges Modification	97 MGD
2. Detention Plan	0 MGD
3. Conservation Plan	211 MGD
4. Multipurpose Plan	95 MGD

Assuming all private and state development occurs as outlined above there will be no need for additional water supply storage until the year 1990 and by 2000 a need for approximately 70 MGD will exist. By the year 2020 a need for 415 MGD will exist. It is expected that by the year 2020 the technology of saline water conversion and waste water reuse will have progressed to the point of making them economically competitive with the development of additional fresh water sources in this area. If this development does occur, there should no longer be any limit to water supply in the study area.

VIII WATER QUALITY CONTROL

Present Waste Loads

At present the majority of municipal and industrial wastes originating within the Passaic River basin are collected and transported out of the basin to either the Hackensack River, Upper New York Harbor or the Arthur Kill. The three agencies responsible for this are the Bergen County Sewer Authority Passaic Valley Sewerage Commission and the Essex and Union County Joint Meeting.

The wastes from over 1,570,000 persons are collected, treated and discharged by these three agencies.

An evaluation of the data included in the inventory reveals that 28.1 MGD of municipal wastes from over 275,000 persons with an assumed organic loading of approximately 7,000 pounds of first stage, 5-day, biochemical oxygen demand (BOD) are discharged in the basin.

Industrial waste discharges total approximately 11.6 MGD with an estimated organic loading of 9,800 pounds of BOD per day. In addition, approximately 379 MGD of cooling water is discharged to the lower Passaic River with the majority of this (370 MGD) discharged by the Public Service Company' Essex Power Station.

It is estimated that the Passaic River, just above its confluence with the Pompton River, receives 15.1 MGD of municipal wastes after secondary treatment and 9.6 MGD of industrial wastes after secondary treatment. The organic loading is estimated to be 3,800 pounds of first stage BOD from municipal wastes and 9,400 pounds of first stage BOD from industrial wastes, for a total of 13,200 pounds of BOD per day.

Additional sources of wastes in the lower portion of the Passaic River below Dundee Dam include oil storage surface leachings, storm water runoffs (which include the discharge of cooling water from many small industrial firms in the lower valley) and the tidal contribution of poor quality Newark Bay waters.

The Passaic River Basin, while currently unclassified according to beneficial use, is regulated and controlled according to wastes discharges by the Passaic Valley Water Commission above Little Falls, N. J., and by the Passaic Valley Sewerage Commission below Little Falls. The Passaic Valley Water Commission has established wastes effluent standards in conjunction with and approved by the New Jersey State Department of Health. See Exhibit 2 in the Appendix for a copy of the Passaic Valley Water Commission standards

Stream Quality Objectives

Under provisions of the Federal Water Pollution Control Act, Public Law 84-660, as amended by Public Law 87-88, in the survey or planning of a reservoir by any Federal agency, consideration must be given to the inclusion of storage for regulation of streamflow for the purpose of water quality control The law expressly states that any such storage and water releases shall not be provided as a substitute for adequate treatment of wastes.

Discharge of municipal and industrial wastes, even when adequately treated, will cause an unsatisfactory quality condition in receiving waters whose wastes assimilation capacity is exceeded. This condition usually, but not always, occurs during the summer months when flows are low and water temperatures high. Poor quality conditions may be avoided by maintaining flows at higher levels.

The storage recommended in this report has been based on maintaining a dissolved oxygen concentration of 4.0 mg/l, 90 percent of the time throughout the fresh water portion of the Passaic River.

By maintaining a dissolved oxygen concentration of 4.0 mg/l, conventional water treatment plants can be assured of producing a potable water acceptable to the public;/most fish and other aquatic life can flourish; and other quality conditions are normally such that the area may be utilized for swimming or other recreational purposes. This statement pre-supposes that the dissolved oxygen concentration is a satisfactory measure of water quality. This is generally the case except where high quantities of unchlorinated domestic wastes are received along with exotic industrial wastes.

Waste Load Projections

Projections of waste loads for the years 1980, 2000, and 2020 assumed that all wastes would receive a minimum of secondary treatment.

Table VIII-1 shows the expected municipal and industrial wastes discharge for the years 1960, 1980, 2000, and 2020. Municipal waste load projections were based on population projections. Industrial waste loads were based on projected industrial water use.

TABLE VIII - 1

Passaic River Basin Waste Load Projections (lbs first stage, BOD/day)

Waste	1960	1980	2000	2020
Municipal	7,000	15,300	23,500	33,700
Industrial	9,800	16,300	18,900	21,600
Total	16,800	31,600	42,400	55,300

Storage For Water Quality Control

The annual drafts on storage requirements recommended in this report for water quality control purposes as based on providing a minimum dissolved oxygen concentration of 4.0 mg/l were computed as the sum of incremental monthly releases required above the natural river flow at Little Falls.

The Passaic River above Little Falls was divided into four reaches based on waste discharges and tributary flows. Reach A extended from mile 66 to mile 58. Reach B extended from mile 58 to mile 48, the confluence of the Whippany-Rockaway Rivers. Reach C extended from mile 48 to mile 33, the Pompton River confluence, and Reach D extended from mile 33 to mile 29.6, Little Falls. For each reach, reaeration coefficients were computed from the Streeter-Phelps equation[10] based on the average dissolved oxygen concentrations shown on Figure V-4, known waste loadings, average flows and time of travel between reaches and an assumed deoxygenation coefficient of 0.15/day (base e) for a stabilized organic oxygen demanding waste. Using the computed reaeration coefficient, equations were developed for exceedence probabilities of 0.1, 0.3, 0.5, 0.7, and 0.9, and projected dissolved oxygen concentrations for each reach were determined from flow duration curves and projected waste loadings.

It was calculated that the maximum annual draft on storage would be 77,000 acre-ft/year in 2020. This maximum occurs as a result of critical oxygen conditions in the reach between the Whippany-Rockaway River confluence and Two Bridges. Consequently, any storage provided for quality control purposes should be adjusted for losses between the release point ant Two Bridges. Figure VIII-1 illustrates the annual drafts on storage requirements at various protection levels to the year 2020. Note that these requirements do not include any adjustment for reservoir losses or transport losses.

Table VIII-2, which gives the maximum average monthly releases to provide the recommended 77,000 acre-ft/year storage is given only to illustrate the distribution of releases which can be expected and should not necessarily be adopted as policy. It is noted that generally the releases will vary directly with the river flow and with minimum releases in the summer months

TABLE VIII - 2

Average Monthly Releases To Provide the Maximum Quality Control Storage (77,000 AF/year)

Month	Flow Release	
	MGD	Ratio of Monthly to Yearly Aver.
January	80	1.15
February	70	1.00
March	55	0.79
April	160	2.30
May	100	1.45
June	70	1.00
July	45	0.65
August	40	0.60
September	35	0.50
October	50	0.70
November	50	0.70
December	80	1.15

and maximum releases in the spring and winter months.

The Reservoir-Tunnel Plan, (Ramapo Detention and Two Bridges Detention modifications) provide a total storage of 37,650 acre-feet. If this entire storage were used for water quality control purposes, an average 75 percent level of protection would be provided.

The Reservoir-Tunnel Plan (Two Bridges conservation pool modification) and the Multipurpose Plan provide storage below the critical quality reach of Paterson, N. J., showed a decrease in population during the past decade, accompanied by an abnormal increase in the nearby suburban municipalities, a trend which is expected by most authorities to continue at an increasing rate.

Population projections to the year 2020, by county and for each of the two study areas was supplied by the New York District, U. S. Army Corps of Engineers. These projections show overall rates of increase from 1960 to 2020 of 108 percent for the Passaic River Basin Area and 109 percent for the Passaic River Service Area. These growth rates are much less than the average predicted for the United States of 179 percent increase over the same period from 1960 to 2020. Table VI-4 shows these data for population projections and Figure VI-1 illustrates the growth rates from the year 1940 to the year 2020 for the entire United States and the two study areas.

Table VI-5 shows growth rates in industrial water use, by county and whether purchased or self-supplied from the year 1960 to the year 2020. These figures were available to the year 1980 from the report on industrial water use by manufacturing industries of New Jersey.(7) Extensions to year 2020 were based on the assumption that industrial water use would continue to grow at a decreasing rate of increase. This is based on two assumptions. First, the available water supply in the Passaic River Service Area will limit the rate of industrial growth. This condition has occurred presently due to the extended drought in the service area causing decreases in industrial production. And second, the continuing effort by industry to reuse and economize water will reduce the ratio of water use to production. The industrial water use rates were increased at a higher rate for the period 1960 to 1980, 43 percent as compared to 39.9 percent and at lower rates for

TABLE VI - 4

POPULATION PROJECTIONS

(1960-2020)

Region	1960	Percent Change 1960-1980	1980	Percent Change 1980-2000	2000	Percent Change 2000-2020	2020
			In Millions				
United St.	180.7	41.7	254.1	41.0	358.3	40.1	502.0
S C A	14.8	42.6	21.1	21.3	25.6	21.5	31.1
			In Thousands				
Service Area							
Bergen	780.3	41.7	1,106.0	22.5	1,355.4	21.9	1,652.3
Essex	923.5	6.3	982.0	4.1	1,022.5	4.3	1,066.8
Hudson	610.7	- 7.5	565.0	0	565.0	7.0	604.5
Middlesex	433.9	102.1	877.0	39.1	1,219.7	33.7	1,630.6
Morris	261.6	106.8	541.0	40.0	757.2	34.2	1,016.5
Passaic	406.6	28.1	521.0	16.7	607.9	16.9	710.7
Somerset	143.9	108.5	300.0	40.3	420.8	34.5	565.8
Union	504.3	27.3	642.0	16.3	746.5	16.5	870.0
Rockland	136.8	152.2	345.0	46.8	506.3	38.3	700.0
Service Area Total	4,201.6	39.9	5,879.0	22.5	7,201.3	22.4	8,817.2
Passaic River Basin	1,544.4	38.2	2,134.4	23.1	2,627.4	22.1	3,208.0

Source: N. Y. District, U. S. Army Corps of Engineers the next two periods; 1980 to 2000 (16 percent as compared to 22.5 percent for population growth) and 2000 to 2020 (12.5 percent as compared to the population growth rate of 22.4 percent). The percent of the industrial water use municipally supplied was increased from the present 39 percent to 41.5 percent for the period 1980 to 2020. This change reflects the needs of industry to obtain high quality water not obtainable from raw water supplies and the increase in municipal water system capacities making them available to industry.

Population projections were used directly to compute projected municipal waste discharges and in conjunction with the municipally supplied industrial water use projections to compute total projected municipal water use.

Industrial water use growth rates were used directly to computed projected industrial water use and industrial waste discharges.

Projections of water use and waste discharges are discussed in further detail in Section VII.

TABLE VI - 5

Industrial Water Use Projections - Growth Rates in Percent

County	1960 - 1980	1980 - 2000	2000 - 2020
Bergen	112.0	20.5	13.0
Essex	38.5	8.5	4.5
Hudson	24.0	10.0	8.5
Middlesex	24.5	10.0	9.0
Morris	68.0	17.0	13.5
Passaic	50.0	24.0	15.0
Somerset	40.5	27.5	23.0
Union	87.5	20.0	16.0
Rockland	40.5	27.5	23.0
Average	43.0	16.0	12.5

Source: Reference No. 7

VII. WATER REQUIREMENTS

The municipal water demand includes all the water required to meet residential, light commercial, small industrial and public water needs which can be reflected in a per capita use figure. Municipal water demand is affected most by the population served and is usually expressed in gallons per capita per day (gpcd). Other factors that have an effect on per capita demand would include an expanding economy, standard of living, climate, supply costs and metering.

The present municipal water demand for the nine county study area was evaluated from the 1963 PHS inventory.(8) The future municipal water demand through year 2020 was then developed by separating the municipally supplied industrial demand, reported in a New Jersey State report(7), from the present municipal water demand. The remaining demand, primarily a domestic use, was projected through year 2020 with an incremental annual increase in usage of 0.5 gpcd. Data for municipally supplied industrial demand projections were supplied by the New Jersey State report(7) through year 1980. Projections through year 2020 were extrapolated from the given data by assuming a decreasing rate of increase.

The industrial water demand includes all water supply demands exerted by the major water using industries. Industrial water demand is affected most by the type of product manufactured. Currently 85 percent of the fresh water used in the manufacturing industries, exclusive of electric power generation, are included in the following SIC categories: Primary Metals, Chemical and Allied Product, Food and Kindred Product, and Pulp, Paper and Paper Products. Other factors that have an effect on industrial water demand would include type of process, amount and rate of production water costs, waste disposal costs and metering.

The present self-supplied industrial water demand for the nine county study area was supplied from the New Jersey State report(7). The future self-supplied industrial water demand through year 1980 was supplied by the New Jersey State report(7). Projections through 2020 were extrapolated from the given data by assuming a decreasing rate of increase.

Present Withdrawals - Municipal

Municipal water systems in the Passaic River basin service area supplied 4,093,600 people in 1962, with an average demand of 540 MGD. Per capita usage averaged 132 gpd.

Table VII-1 shows the 1962 municipal water use for the nine county service area with a breakdown as to surface and ground-water supplies, and per capita usage.

TABLE VII - 1

1962 Municipal Water Use

County	Population Served (Thousands)	Percent of Cnty Popul.	Water Use, MGD			Use Per Capita GPD
			Surface	Ground	Total	
Rockland	139.9		9	4	13	96
Bergen	739.2	95	60	19	79	106
Union	504.6	100	46	18	64	146
Middlesex	411.0	95	24	29	53	128
Essex	920.2	100	104	23	127	139
Hudson	610.3	100	94		94	155
Passaic	408.7	95	64	7	71	173
Somerset	114.7	80	9	2	11	92
Morris	245.1	94	5	23	28	114
TOTAL	4,093.6		415	125	540	132

Source: Reference No. 8

Present Withdrawals - Industrial

Industrial water demands totalled 520 MGD in 1962, 315 MGD of which was self-supplied. Table VII-2 shows the 1962 industrial use for the nine county service area with a breakdown of the portions municipally supplied and self-supplied.

Existing Sources - Municipal

The major portion of the municipal demand, 415 MGD or approximately 77 percent of the total, is supplied from surface sources. Groundwater sources, primarily drilled wells, provide the remaining 125 MGD or 23 percent. Approximately 83 percent of the total municipal demand is supplied by large water companies with the remainder supplied by individual communities and small developers. Nearly 65 percent of the total municipal supply is within the Passaic River Basin. The major municipal water suppliers are the Hackensack Water Company, Passaic Valley Water Commission, Jersey City Water Department, City of Newark, North Jersey District Water Supply Commission, Commonwealth Water Company, Middlesex Water Company, Elizabethtown Water Company, City of New Brunswick, and the Spring Valley Water Company.

Hackensack Water Company

The Hackensack Water Company currently serves a population, which is located primarily in Bergen County, of approximately 660,000, with an average demand of 70 MGD. This company has developed the Hackensack River Basin above the head of tide at New Milford, N. J. Three storage reservoirs Oradell and DeForest Lake on the Hackensack River; and Woodcliff Lake on Pascack Brook, a tributary of the Hackensack provide a dependable yield, estimated by the company, of approximately 75.0 MGD. Ten MGD of this total is reserved by the approval of the New York State for the DeForest Lake Reservoir for use in New York State when required. Additional water is

TABLE VII - 2

1962 Industrial Water Use

County	Water Use, MGD		MGD Total
	Municipally Supplied	Self-Supplied	
Rockland*	2	28	30
Bergen	20	15	35
Union	33	21	55
Middlesex	25	108	133
Essex	57	20	77
Hudson	34	16	50
Passaic	28	24	52
Somerset	2	23	25
Morris	4	60	63
Totals	205	315	520

*Figures estimated from use rates for Somerset County because of lack of data.

Source: Reference No. 7

available through purchase contracts with the Passaic Valley Water Commission and Jersey City from the Passaic River Basin for an average of 10 MGD with up to 13 MGD for peak demands. Current impounding storage totals 9.6 billion gallons. The water receives complete treatment consisting essentially of chemical coagulation, rapid sand filtration and ammoniation with chlorination.

Passaic Valley Water Commission

This system currently serves 393,900 persons with an average demand of 67 MGD. The sources of its supply include the Wanaque and Ramapo Rivers, via the North Jersey District Water Supply Commission (48 percent), Pancake Hollow Reservoir providing off-channel storage of Pompton River Water, and the Passaic River. The estimated dependable yield of this system is 75 MGD. Wanaque and Ramapo River waters are treated by pressure filtration and rechlorination. Pompton and Passaic River waters are treated by chemical coagulation, sand filtration, pH control and chlorination.

Jersey City Water Department

The Jersey City system serves a total population of 364,000 persons with an average demand of 60 MGD. The source of this supply is the Rockaway River via the Split Rock and Boonton Reservoirs. The dependable yield of this system is presently 71.2 MGD. With the completion of the Upper Longwood Valley Reservoir on the Rockaway River the dependable yield is expected to increase to 84.2 MGD. Treatment of this supply consists of fine screening, chlorination and ammoniation.

City of Newark

Newark supplies approximately 593,000 persons with an average demand of 98 MGD. Sources for this supply include five reservoirs in the Pequannock River watershed--Canistear, Oakridge, Clinton, Charlotteburg, and Echo Lake--and bulk purchases from the North Jersey Water Supply Commission. The dependable yield of the Pequannock reservoir system is 58.7 MGD. Treatment is provided only for the Pequannock waters and consists of chlorination, ammoniation, pH correction and aeration.

North Jersey District Water Supply Commission

This system presently serves a population of 208,550. In addition, as previously mentioned, it also provides approximately 48 percent of the Passaic Valley Water Commission's demand and approximately 43 percent of Newark's requirements. The total average demand on this system is 110 MGD. The source of this supply is the Wanaque storage reservoir on the Wanaque River plus an additional 25 MGD annual average pumped diversion from Ramapo River at Pompton Lakes. Treatment of this supply consists of chemical treatment by ammonia, lime and chlorine.

Commonwealth Water Company

This system serves 212,870 persons in Union, Essex and Morris Counties, with an average demand of 22 MGD. The source of its supply is on-channel diversion from the Passaic River, off-channel storage of pumped diversion from Canoe Brook and 25 drilled wells. The dependable yield of this system is estimated at 16.0 MGD from the Passaic River and Canoe Brook and 15.0 MGD from the drilled wells. Treatment consists of chlorination of the well supply and chemical coagulation, settling, rapid sand filtration and chlorination of the surface supplies.

Middlesex Water Company

This system serves 147,500 persons in Union and Middlesex Counties with an average of 17.6 MGD. The source of its supply is from a small storage reservoir on a tributary of the Rahway River and 30 drilled wells. The small reservoir provides a dependable yield of 2.0 MGD and the wells a yield of 15.6 MGD. Treatment of the surface supply consists of chemical coagulation, settling, rapid sand filtration and chlorination. Chlorination is the only treatment provided for the well supply.

Elizabethtown Water Company

This system presently serves approximately 447,000 persons in Union, Middlesex, and Somerset Counties with an average of 39.3 MGD. The sources of its supply include on-channel diversion at the junction of the Raritan and Millstone Rivers, contractual purchases of Delaware River water via the Delaware River and Raritan canal and 123 drilled wells located throughout the company's service area. The on-channel diversion is limited to a maximum daily withdrawal of 20 MGD by 1918 conditional approval under R. S. 58.1. The contractual sales of Delaware River water total 22.5 MGD with 10 MGD additional under emergency contract. The well supply yields 10.0 MGD. Treatment consists of chemical coagulation, settling, rapid sand filtration and chlorination.

New Brunswick Water Department

The City of New Brunswick presently serves 64,500 persons in Middlesex County, with an average demand of 12.0 MGD. The source of this supply includes Farrington Reservoir located on a tributary of the lower Raritan River and contractual purchases of Delaware River water via the Delaware and Raritan Canal. The dependable yield of this system is presently 18.0 MGD.

Spring Valley Water Company

This system presently serves approximately 100,000 persons in Rockland County, New York, with an average demand of 9.0 MGD. Raw water is obtained from the Hackensack River via DeForest Lake Reservoir and 29 drilled wells. DeForest Lake presently provides a dependable yield of 10.0 MGD and the wells a yield of 16.0 MGD. There is presently an untapped reserve of 5.0 mg in Lake DeForest which could be utilized if necessary in the future.

Treatment consists of chemical coagulation, settling, rapid sand filtration and chlorination.

Other Supplies

Other systems in the Passaic Basin service area which are primarily using groundwater sources, serve a combined population of approximately 591,300 with a total demand of approximately 76 MGD. The total combined dependable yield of these other systems is approximately 185 MGD.

Table VII-3 shows the population served, demand and dependable yield of the major water systems in the service area.

TABLE VII - 3

Major Water Systems - Service Area

Company	Pop. Served	1962 Demand, MGD	Dependable Yield MGD Surface	Dependable Yield MGD Ground
Hackensack Water Co.	660,000	70.00	70.8	4.2
Passaic Valley Water Commission	393,900	67.10	75.0	0
Jersey City Water Dept.	364,000	60.00	84.2	0
Newark Water Dept.	593,000	98.00	58.7	0
North Jersey District Water Supply Comm.	208,550	33.80	105.0	0
Commonwealth Water Company	212,870	22.0	16.0	15.0
Middlesex Water Company	147,500	17.60	2.00	15.60
Elizabethtown Water Company	446,550	39.30	52.50	10.00
Spring Valley Water Company	100,000	9.00	10.00	16.00

Company	Pop. Served	1962 Demand, MGD	Dependable Yield MGD	
			Surface	Ground
New Brunswick Water Dept.	64,500	12.00	18.00	0
East Orange	77,000	7.00	0	10.00
Fairlawn	38,000	3.25	0	6.00
Perth Amboy	38,500	10.00	0	12.00
Essex Fells	38,800	3.00	0	4.00
Orange	36,000	4.00	1.7	3.70
Morristown	45,000	5.00	1.4	7.50
Other Systems	591,330	76.75	24.70	159.10
TOTAL	4,093.6	540	520	270

Source: Reference No. 8

Future Withdrawal Water Needs and Sources

The future water needs of the Passaic River Basin service area, through the year 2020, are summarized by county in Table VII-4. This table includes the predicted demands on municipal systems, that portion of the municipal demand used by industry and the industrial self-supplied demand. The total municipal demand by the year 2020 is expected to be approximately 1,365 MGD. The demand from self-supplied industries is expected to be approximately 565 MGD. The overall total demand is then approximately 1,930 MGD.

The present dependable yield of municipally developed water supplies in the service area including present interbasin transfers from the Delaware River basin is approximately 790 MGD. To this may be added 200 MGD from the recently completed Spruce Run-Round Valley development in the Raritan River Basin which will supplement the Passaic River Basin by supplying the Newark-Elizabeth area. Round Valley reservoir is located on the divide between the

TABLE VII - 4

Future Water Use - Passaic River Basin Service Area

County	Total Municipal 1/ MGD			Industrial Use 2/ Municipally Sup. MGD			Industrial Use Self 2/ Supplied, MGD		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
Bergen	140	185	240	40	50	55	25	30	35
Essex	165	185	200	80	85	85	20	25	30
Hudson	105	110	125	40	45	50	20	20	25
Middlesex	105	150	210	35	45	50	125	135	145
Morris	65	95	140	5	10	10	95	110	120
Passaic	90	120	145	35	45	55	40	45	50
Somerset	30	45	65	5	5	5	30	40	50
Union	105	130	160	60	70	80	35	45	50
Rockland*	35	55	80	5	5	5	40	50	60
TOTALS	840	1075	1365	305	360	395	430	510	565

*Figures estimated from Somerset County figures for Industrial Use.

1/ Figures based on USPHS 1963 Inventory of Municipal Water Facilities.

2/ Figures based on State of N.J. Report on Present and Prospective Use of Water by Manufacturing Industries of New Jersey.

(610,737), and Paterson-Clifton-Passaic, N. J. (1,186,873). These SMSA along with Middlesex County, N. J. (433,856) and Somerset County, N. J. (143,913) lie within the greater New York metropolitan area with a 1960 population of 14,759,429. Population densities vary from a low of approximately 470 persons per square mile in principally rural Somerset County to nearly 14,000 per square mile in the heavily populated and industrialized Hudson County.

Available resources influencing industrial expansion and growth would include land, water, climate, labor market and transportation. The economy of the area is largely dependent on the processing, refining, upgrading and manufacturing of raw materials imported from other parts of the United States and from foreign countries. The natural resources within the study area are presently suited for continued rapid expansion and growth and are not expected to restrict or limit economic development. It is expected that future economic growth will depend to a large extent on development of more effective transportation systems and development of water supplies of adequate quality and quantity. Presently, the area is served by major modern highways from the east, west, north and south; rail service to the major cities; a well established and rapidly growing trucking industry; major air service at Newark, N. J. and Teterboro, N. J.; and ocean vessels at Port Newark and Elizabeth.

Employment in principal industrial groups for the nine county study area as of 1962 is shown in Table VI-1 and indicates the following employment picture: 51.9% in manufacturing, 20.3% in wholesale and retail trade, 8.9% in service activities, 5.0% in contract construction, 8.4% in transportation, communications and utilities, 4.4% in finance and 1.1% in all other classifications. The manufacturing industries comprising 634,418 employed persons

TABLE VI - 1

1962 Employment by Type of Industry For the Nine County Service Area

Industrial Group	Number Employed
Manufacturing	634,418
Wholesale & Retail Trade	248,344
All Services	109,005
Contract Construction	60,878
Transportation, Communications, & Utilities	102,117
Finance & Insurance	53,299
Other	13,220
Total Employment	1,221,281

Source: Reference No. 15 and 16

in 1962 are the principal industries for the study area as well as the State of New Jersey. A total 76% of the State of New Jersey manufacturing industries in 1962 were located in the 8 counties (excluding Rockland County, N.Y.) included in the service area. Manufacturing activities are concentrated within the counties included in the service area. Essex County has the largest share of manufacturing employment, 16% of the State total, with 1,030 workers per square mile, and Hudson, Bergen, Union, Passaic and Middlesex follow in that order. Rockland County, N. Y. is not as heavily industrialized as the eight New Jersey counties and in 1962 employed 11,800 persons in manufacturing activities.

A break down of 1962 manufacturing employment for the nine county service area is included in Table VI-2. Manufacturing industries account for over 90 percent of the total industrial water demand of which about 85 percent of the fresh water demand, exclusive of power generation, is contributable to the major water using manufacturing industries including Primary Metals, Chemical and Allied Products, Food and Kindred Products and Pulp, Paper and Allied Products. These water using industries comprise 28 percent of all manufacturing in the service area.

TABLE VI - 2

1962 Manufacturing Employment
for the Nine County Service Area

	EMPLOYMENT	
ALL MANUFACTURING	634,418	
Electrical Goods & Mach.		92,800
Chemicals		77,002
Apparel		61,500
Food		45,096
Machinery (Ex. Elec.)		48,570
Febricated Metal Prod.		42,228
Primary Metal Industries		30,234
Stone, Clay & Glass Prod.		15,350
Instruments and Clocks		29,628
Rubber and Plastics		23,177
Paper		25,910
Textile Mill		12,864
Leather		9,246
Petroleum Refining		6,581
Printing & Publishing		26,550
Aircraft Industry		15,938
Automobile Industry		12,143
Other		59,601

Source: Reference 15 and 16

Future

Past and present population figures by county are shown for the two study areas, Passaic River Basin Area and Passaic River Service Area, in Table VI-3. From 1940 to 1960 the population within both areas increased approximately 13.8 percent. The increase for the entire United States over this same period was 13.7 percent or essentially the same as that for the two study areas.

All of the major cities within the two study areas with the exception

TABLE VI - 3

PAST AND PRESENT POPULATION - PASSAIC RIVER BASIN AND PASSAIC RIVER SERVICE AREA

	PASSAIC RIVER BASIN			PASSAIC RIVER SERVICE AREA		
COUNTY	1940	1950	1960	1940	1950	1960
Bergen	148,000	195,000	282,000	409,600	539,100	780,300
Essex	501,000	542,000	552,000	837,300	905,900	923,500
Hudson	24,900	24,700	23,300	652,000	647,400	610,700
Middlesex	-	-	-	217,100	264,900	433,900
Morris	103,500	135,000	214,800	125,700	164,400	261,600
Passaic	290,000	316,000	380,400	309,400	337,100	406,600
Somerset	12,800	17,100	24,800	74,400	99,100	143,900
Union	22,100	26,800	33,900	328,300	398,100	504,300
Rockland	18,000	21,700	33,150	74,300	89,300	136,800
TOTAL	1,120,300	1,278,300	1,544,350	3,028,100	3,445,300	4,201,600

YEAR	1940	1950	1960
USA (X1000)	131,670	150,700	180,700

Source: Reference No. 6

V. WATER RESOURCES OF THE STUDY AREA

Surface Water

For purposes of describing the basin hydrologically it has been divided into two portions; the fresh water portion above Dundee Dam, river mile 17.4, and the tidal portion below Dundee Dam.

The fresh water portion is characterized by stream flow at the Little Falls USGS gaging station with a drainage area of 762 square miles. (81.5 percent of the basin). The tidal portion is characterized by flows at the mouth of the Passaic River at Newark Bay.

Average flow of the Passaic River at Little Falls, based on 66 years of record is 1,182 cfs. Maximum daily discharge was 28,000 cfs and the minimum daily discharge was 32 cfs. The minimum daily discharges expected once in 10, 5, 3.3, 2.5 and 2 years are given in Table V-1.

TABLE V-1

Recurrence of Flows of Passaic River at Little Falls

Recurrence Interval Yrs	Minimum Daily Discharge MGD
10	78
5	130
3.3	194
2.5	300
2	450

Major tributaries to the Passaic River above Dundee Dam include the Whippany and Rockaway Rivers at river mile 47.0, and the Pompton River at river mile 33.0. Major tributaries to the Pompton River include the Wanaque, Pequannock and Ramapo Rivers. Table V-2 illustrates the percent of the total flow at Little Falls that is contributed by the Whippany and Pompton Rivers at various recurrence intervals.

TABLE V - 2

Percent of Flow at Little Falls by Whippany and Pompton Rivers

River	Percent of flow at Little Falls with given recurrence interval				
	10 yr	5 yr	3.3 yr	2.5 yr	2 yr
Whippany	29	22	18.5	14.5	12.5
Pompton	66.5	58	52	44	39

Stream flow of the Passaic River at its mouth was computed by synthesizing records from the Peckman River, Molly Ann's Brook, Goffle Brook and Diamond Brook, and by using existing Geological Survey records for the Passaic at Little Falls, Saddle River at Lodi, Weasel Brook at Clifton and the Second River at Belleville, N. J. This computation yields an average flow of 1,380 cfs. The minimum daily discharges expected once in 10, 5, 3.3, 2.5 and 2 years are given in Table V-3.

TABLE V - 3

Recurrence of Flows of the Passaic River at its Mouth

Recurrence Interval Years	Minimum Daily Discharge MGD
10	110
5	175
3.3	250
2.5	375
2	545

The tide at Newark, N. J., is classified as semidiurnal and the tidal cycle has a period of approximately 12.4 hours. A 24 year study conducted by the U. S. Army Corps of Engineers, Tidal Surveys Section, indicates a mean tidal range of 5.24 ft with a spring range of 6.30 ft. The flushing times in the tidal portion at the 10 and 2 year low flows are given by Table V-4 and Figures V-1. These data are based on calculations by the Tidal Prism method.(1)

TABLE V - 4

Flow vs Detention Time in Tidal Portion

Flow Recurrence Interval	Flow MGD	Flushing Time for 95% of Flow
10 yr	110	17 days
2 yr	545	10½ days

Accumulated time of passage in the fresh water portion versus river miles with the proposed channel improvements is given by Figure V-2. These curves were computed by Manning's equation for open channel flow using channel data provided by the Corps of Engineers, New York District Office and flow duration curves based on Geological Survey stream flow records.

Ground Water(14)

The extreme northwestern portion of the Passaic River Basin, generally that area north and west of Morristown, N. J., has been classed geologically as the Highlands and Appalachian Valley Provinces. In the Appalachian Valley farthest to the northwest, the rocks are composed of limestone, shale and sandstone or quartzite, while in the Highlands area, composing most of Morris County, crystalline metamorphic and igneous rocks predominate. These rocks are generally not favorable for the production of large supplies of ground water, although some wells may yield 100 gallons per minute or more in areas where water bearing openings have been enlarged by solution.

Glacial deposits form a discontinuous mantle over all of the Highlands and Appalachian Valley Provinces. Where the glacial debris covers the upland areas, the material is largely clayey and is generally not productive of large ground-water supplies. However, in some of the principal stream valley there are stratified deposits of sand and gravel that yield supplies of sigificant importance for local use. Yields in the Appalachian Valley and Highland Provinces range from 10 - 100 gpm. The remainder of the basin including parts of Middlesex, Morris and Passaic Counties and most or all of Somerset, Union, Essex, Hudson and Bergen Counties lies within the Piedmont Plain Province. The surface of the Piedmont Plain is underlain by sandstones, shales and trap rock. Unconsolidated glacial or related deposits mantle most of the province.

The sandstones and shales generally yield small to moderate supplies to wells. In the eastern part of Somerset County and the western part of Union County, through the central part of the province, moderate to large yields have been obtained from these formations. The trap rock, of which there are many outcrops in the Piedmont Plain Province, is one of the poorest of all rocks for obtaining ground water supplies. The glacial deposits are favorable for ground-water development only in areas where they consist of stratified sands and gravels. Such occurrences are spotty and poorly defined. In general, much of the area of the glacial deposits is composed of clayey drift which is unfavorable for ground water supply. Yields in this province range generally from 100 to over 500 gallons per minute. The ground-water potential of the Highlands and Appalachian Valley provinces is limited to scattered localities within the outcrop areas of limestone and to coarse sands and gravels deposited by glacial streams. Neither of these potential sources has been carefully investigated and at present there is no basis for estimating the maximum utilization that may be made.

The withdrawal of water in many localities within the Piedmont Plain is about the maximum that can be pumped without causing declining water leve and it is questionable whether or not additional large supplies can be obtained in these existing well fields. It is probable that by geophysical surveys, test drilling and additional geological surveys, the courses of the streams that deposited highly permeable sands and gravels can be ascertained and additional well fields developed. It is estimated that an increase in withdrawal of approximately 30 - 40 million gallons per day may be possible from new wells drilled in the outwash gravels where river infiltration from nearby streams can be utilized.

Water Quality

Water quality data in the Passaic River Basin are collected routinely by the Passaic Valley Water Commission, Passaic Valley Sewerage Commission, and the New Jersey State Health Department.

In addition to data routinely collected the following special surveys have been made:

1. Joint survey of streams within the Passaic River drainage area--conducted by the Geological Survey of the U. S. Department of Interior, New Jersey State Department of Health, and the Passaic Valley Water Commission. Investigation extended from June 25, 1963 to January 28, 1964 and from June 16, 1964 to September 1964.

2. Public Health Service survey of the lower (tidal portion) Passaic River on August 19, 20 and 24, 1964. This survey consisted of nine (9) sampling stations from river mile 1.0 to 16.0. Table V-5 shows the average of the three sampling runs for each parameter studied. All analytical work was done at the Public Health Service laboratory in Metuchen, N. J., in

accordance with methods outlined in the 11th Edition of Standard Methods for the examination of Water and Wastewater. The membrance filter technique was used for bacteriological analyses.

Table V-6 and Figure V-3 summarize all the water quality data available, period of records available and station locations.

A number of figures have been plotted from Public Health Service data obtained from the survey outlined above, and from Passaic Valley Water Commission data. The figures are intended to represent critical conditions at key points within the basin in an attempt to characterize existing water quality.

Figure V-4 presents the average dissolved oxygen (DO) profile for the Passaic River from mile 4.3 to mile 66.8 for four seasons of the year 1963; the DO profile from Little Falls to Millington for five probability levels and the monthly variation of DO at Little Falls and Two Bridges for four probability levels.

Figure V-5 illustrates the chloride profile along the Passaic River from its mouth to Millington and total and fecal coliform concentrations in the tidal portion of the Passaic River.

Figure V-6 shows water quality profiles of the Passaic River below Dundee Dam and above Little Falls for the following parameters:

a. Nutrients (organic nitrogen, nitrates, phosphates)

b. Color, turbidity, phenol

c. BOD (Biochemical Oxygen Demand)

Figure V-7 shows water quality profiles of the lower Pompton River from mile 0.0 to 6.5 and the Whippany River from mile 0.0 to 13.3.

TABLE V - 5

Average Values of Parameters Studied in Specific Survey of the Lower Passaic River by PHS, August 19, 20, and 24, 1964

Station Location (River Miles From Passaic Mouth)	16.0	15.6	15.0	12.8	8.5	5.8	4.3	1.5	1.0
Temp. °C	24.1	23.0	23.5	23.5	23.7	24.0	23.0	24.5	23.0
DO, mg/1	14.4	1.5	2.63	0.72	2.95	0.35	0.1305	0.13	0.8
BOD, mg/1	12.2	17.4	15.7	9.0	5.7	4.2	4.6	7.6	6.9
COD, mg/1	78	75	63	62	95	113	116	156	139
Org N	1.37	0.63	1.50	1.78	2.02	1.83	2.03	2.26	2.84
NO_2	0.04	0.08	0.02	0.04	0.03	0.01	0.01	0.005	0.02
NO_3	0.24	0.54	0.05	0.09	0.05	0.03	0.02	0.00	0.02
PO4	1.30	4.13	1.25	1.67	1.30	2.15	1.97	2.24	2.23
Phenols	8	41	27	16	14	12	12	94	56
Color	138	67	88	76	62	49	56	69	57
Turb	102	28	62	62	50	41	44	43	31
Chlorides	75	60	74	720	5,100	8,200	10,230	10,800	11,300
Total Solids	436	369	414	1,650	10,300	17,200	20,000	22,200	21,600
Suspended Solids	47	16	26	28	31	21	27	35	37
pH	8.5	7.3	7.5	7.4	7.1	6.9	6.6	7.2	7.2
Total Coli. Org/100 ml	24,900	95,300	95,300	6,900	2,300	103,400	62,300	213,000	
Fecal Coli. Org/100 ml	1,500	11,900	9,700	400	270	3,100	5,800	23,300	

NOTE: All samples collected at high water slack tide.

TABLE V - 6

AVAILABLE WATER QUALITY DATA WITHIN PASSAIC RIVER BASIN

PARAMETERS STUDIED	PVWC(1)	PVSC(2)	NJSHD(3)	NJSHD, USGS, AND PVWC SPEC. STUDY	PHS SPEC. STUDY
Temp., Turbidity, Color, pH, Cl^-, D.O.	x	x	x	x	x
NO_2, NO_3, BOD	x		x	x	x
Odor, Alkalinity, Hardness	x		x	x	
Iron, Aluminoid			x	x	
Ammonia	x				
SO_4, F, N, PO_4, ABS				x	
Organic, Phenols					x
Solids: Settleable					x
Total	x		x	x	x
Fixed, Volatile			x	x	
Coliforms: Total	x		x	x	x
Fecal					x
Portion of Basin Samp.	Passaic & Major Trib. Above Little Falls	Passaic & Trib. Below Little Falls	Entire Basin	Passaic & Major Trib. Above Little Falls	Lower Passa Below Dunde
Number of Stations	43	12	21	14	9
Frequency of Samples	Once or twice per Mo.	Once per week	Two-Four Times Per Year	Once per Month	Once Daily
Period of Record	From 1949	From 1945	From 1958	6/63-9/64	Aug 19,20,24 '64

(1) PVWC - Passaic Valley Water Commission
(2) PVSC - " " Sewerage Commission
(3) NJSHD- New Jersey State Health Dept.

VI. ECONOMY

Scope

Economic data presented in this section serves as the basis for estimating future municipal and industrial water demands and waste discharges. Population data were provided by the Corps of Engineers. Basic data used for projections of municipal and industrial water use and waste discharges for the study period were provided by Public Health Service inventories(8,9) along with the New Jersey report on present and prospective use of water by manufacturing industries(7).

These data were developed for the two study areas used in this report. The first study area, the Passaic River nine county service area used for evaluation of water requirements, was defined to include all of Rockland County, N. Y. and all of Morris, Somerset, Passaic, Essex, Bergen, Hudson, Union and Middlesex Counties in N. J. The second study area, the Passaic River Basin area used for evaluation of waste discharges, was defined to include all or part of the above mentioned counties with the exclusion of Middlesex County in N. J.

Present

The Passaic River Basin nine county service area, located predominantly in the northeastern portion of New Jersey, had a 1960 population of 4,201,600 persons and the Passaic River Basin area had an approximate 1960 population of 1,544,350 persons. The 1960 populations by county are included in Table VI-3 and Table VI-4. The population centers within the nine county service area include the following Standard Metropolitan Statistical Areas (SMSA) and 1960 populations: Newark, N. J. (1,689,420), Jersey City, N. J.

in the following manner:

1. Increased surface reaeration rate due to turbulence and an associated increase in dissolved oxygen concentrations.

2. Scouring of bottom solids and thus an increase in BOD and turbidity concentrations and reduction in sludge banks that result from the settling of organic solids.

There will be an interchange of waters between the conservation and wildlife portions of the reservoir to maintain satisfactory water levels in each portion. Waters from the shallow, poor quality wildlife pool could significantly affect the quality in the conservation pool. Consideration should be given to the possible degrading effects of this interchange of waters.

The outlet works of the reservoir will draw from a depth of 19 feet. Because of possible temperature stratification during the critical summer months the dissolved oxygen concentration in the augmenting flow is expected to be significantly less than saturation. However, following the outlet works is a stilling basin which should replace any dissolved oxygen lost by stratification by turbulent hydraulic mixing. The dissolved oxygen concentration in the reservoir releases is then expected to be in the range of 90 to 100 percent of saturation.

Central Basin Reservoir - Dry Detention Plan

It is expected that this project will not result in any significant changes in water quality other than those associated with the construction stage, because it does not entail any impoundment or storage of water.

Central Basin Reservoir - Partial Development Plan

This plan would affect water quality in two ways--by the conservation storage pool and by the diversion of Pompton River waters to the conservation pool which removes this flow from the Passaic River.

The conservation pool as presently planned will flood a large portion of the previously described Great Piece Meadows swamp area. Unless the swamp muck material is removed or mechanically stabilized, the muck may be a continuing source of BOD as well as color, taste and odor constituents. Natural stabilization would most likely occur, but would be dependent on many factors including the composition and depth of the meadow-mat. Information available at this time is not sufficient for a proper evaluation of the effect on water quality of the meadow-mat or the length of time that may be required for the mat to stabilize.

The conservation pool at elevation 176.5 feet msl would flood approximately 6,290 acres and store 70,000 acre-feet of water. The average depth would then be approximately 11 feet. The relatively shallow nature of such a pool is a source of concern in terms of problems in marginal areas as well as problems in the main body of the pool. Assuming large drafts for water supply, power supply, and flow regulation for water quality control purposes during summer drought periods, extensive shallow areas of the reservoir would occur. Shallow depths of marginal areas would encourage the development and growth of mosquitoes which would be undesirable from a standpoint of potential recreational uses. These marginal areas of the pool would also encourage seasonal development of weed growths. In addition to contributing to the mosquito propagation potential, such weed growths might be expected to contribute to the organic wastes load to the pool by subsequent die off and decay.

The water within the main body of the pool, although entering as good quality Pompton River water, will be of questionable quality due to the previously discussed swamp bog material. There is need of further study of this problem.

It is not anticipated that there will be any problem due to eutrophication because of the relatively low nutrient load carried by the Pompton Rive However, algal blooms have been known to occur at lower concentrations of nitrates and phosphates than those observed in the Pompton River and consideration of possible eutrophication should be given.

Diversion and storage of Pompton River water will adversely affect the quality of the Passaic River below the dam site, and at the Little Falls water treatment plant intake, since most of the assimilative capacity of the Passaic in this area is due to Pompton River water. This condition then requires dependable releases from the Pompton outlet works to maintain satisfactory conditions in the Pompton River below the Pompton diversion dam and in the Passaic River to the water treatment plant at Little Falls. Low flow releases are discussed further in the subsequent section on flow regulation. Releases from the Pompton outlet works will pass through a stilling basin which should aerate releases to near saturation of dissolved oxygen concentrations.

Central Basin Reservoir - Maximum Development

This plan, consisting of one multipurpose reservoir at the Two Bridges site, will retain both Pompton and Passaic River waters flooding the swampy bog areas previously described.

The influent water quality of the Pompton River is, as previously discussed, of good quality with a satisfactory dissolved oxygen concentration, low BOD, low coliform counts and relatively low nutrient concentrations. At present the Pompton and its tributaries receive approximately 430 pounds of first stage BOD per day from municipal and industrial waste sources. This compares to the low quality Passaic River water with low dissolved oxygen, high coliform counts, high nutrients, and an approximate BOD load of 13,200 pounds per day.

It is expected that nuisance conditions will prevail in the reservoir near the confluence of the Whippany and Rockaway Rivers with the Passaic River. At this site many shallow areas of less than five feet of water depth will occur. Organic solids carried by the two rivers, Whippany and Rockaway, could settle out in these shallow areas creating organic sludge banks which would result in septic and odorous conditions. In addition, the nutrient load carried by these two rivers is high, being over 1 mg/l as organic nitrogen, with the concentration of the combined Passaic, Whippan and Rockaway Rivers over 4.0 mg/l organic nitrogen. This load not only is oxygen demanding, thus depleting the dissolved oxygen concentration, but will also result in heavy algal blooms causing associated taste, odor and color problems. The above problems are compounded by the organic oxygen demanding bog material which underlies the majority of the reservoir. Quality in the downstream portion of the reservoir will be much improved due to the mixture of the Pompton River waters and the time decay of much of the upstream BOD and coliform concentrations. Lack of data concerning this reservoir prevents a more detailed analysis. It is anticipated, however, that eutrophication of the reservoir would progress with time since algae would be carried downstream, due to currents and growth. The plants when they die would settle out thereby contributing to the downstream nutrient load.

The outlet works of the reservoir will be located at an approximate elevation of 156.0 feet msl followed by a stilling basin. The depth of water at the intake will be approximately 24.0 feet and stratification is expected to occur during the summer months with a substantial decrease in the dissolved oxygen concentration. Some recovery will occur in the stilling basin so that it is expected that the resulting dissolved oxygen concentration will be in the order of 80 - 90 percent of saturation.

In addition to poor influent water quality, and potential development of color, taste and odor constituents, the large landfill operation presently located within the reservoir site must be considered. This landfill presently receives from North Jersey communities more than 1,000 tons of refuse per week including domestic garbage, industrial chemicals, industrial wastes, septic tank pumpage, and other unclassified wastes which have been disposed of in this general area for more than a century. If any portion of the landfill is inundated, the water quality problems will be magnified. Dikes or other structures to prevent erosion of landfill materials and to reduce the amount of leachate seeping into the river would be necessary to guard against this potential source of additional direct pollution of the proposed reservoir.

IV. STUDY AREA

The Passaic River, draining an area of approximately 935 square miles, is situated predominantly in the northeastern portion of New Jersey and partly in southeastern New York. The basin is roughly elliptical in shape with a northeasterly length of about 56 miles and a maximum width of 28 miles. Population density varies from the heavily populated cities of the New York metropolitan area to the almost deserted hills of the Ramapo Mountains.

The watershed is divided into three distinctly separate physiographical regions with differing hydrologic and geologic characteristics. Figure IV-1, the study area map, shows the general location of the Passaic Basin and the three regions.

The study area used as the basis for the projection of municipal and industrial water supply needs consisted of nine counties including Bergen, Essex, Hudson, Middlesex, Morris, Passaic, Somerset, and Union in New Jersey and Rockland in New York. This large area was chosen irrespective of water supply storage available from the proposed project since the use of any storage developed will be by the major water companies which serve the entire area outlined above.

The area used as the basis for the projections of municipal and industrial wastes discharges consists of the Passaic River Basin which includes all of Passaic County and portions of Union, Essex, Bergen, Morris, and Somerset Counties in New Jersey and a portion of Rockland County in New York. This designation is based on the concept that only wastes originating within the basin will be discharged in the basin. The population of the nine county area is greater than the population within the hydrological confines - 4,201,600 compared to 1,544,350 people.

Geography

The Passaic River has its headwaters in the Central Basin north of Millington, N. J. It then flows south through the Great Swamp area and turns northeast below Millington. This northeasterly direction is followed to Paterson, N. J., from which the river then turns due south to its confluence with Newark Bay.

The Passaic River basin, as previously mentioned, has been divided into three distinctly separate physiographical regions with differing hydrologic and geologic characteristics. The largest region, called the Highland Area, comprises about 55 percent of the total watershed area and occupies the northwestern half of the basin. The next largest, the Central Basin, is located in the southerly portion of the watershed and constitutes a little over 25 percent of the total area. The smallest, called the Lower Valley, comprises only about 20 percent of the watershed and occupies the eastern fringe.

The Highland area is a wooded mountainous region which is the eastern edge of the Appalachian Highlands. It is characterized by a series of parallel ridges and valleys running in a generally northeastern direction. The terrain is rugged and the narrow, steep-sided valleys contain many natural and manmade lakes. In general, the area is sparsely settled and supports relatively few industrial or manufacturing establishments. It has been developed extensively for municipal water supplies.

The Central Basin with elevations varying from 150 to over 500 feet above sea level is characterized by small hills, flat meadowlands and extensive areas of fresh water swamps. Some rural areas remain, but primary development at present is for residential uses and smaller industrial facilities.

The Lower Valley is essentially a flat, wide flood plain with abutting, low rolling hills and comprises some of the most densely populated and highly developed land in New Jersey. The portion of the Passaic River below Dundee Dam, approximately 16.0 miles, is tidal.

Climate

The Passaic River basin lies in the track of most east coast storms and is consequently subject to frequent rainfalls of great intensity. Rainfall is due primarily to late summer storms originating over the ocean to the south, fall or hurricane storms, spring storms originating over the continent to the west and southwest, and local thunderstorms.

The average annual precipitation varies from approximately 51 inches in the Highlands area on the Upper Rockaway River to 44 inches in the Lower Valley near Newark, N. J.

Typical annual precipitation for a dry year, as measured by 1930 records, varies from a high of 38 inches in the Upper Rockaway to a low of 36 inches near Newark, N. J.

Table IV-1 gives temperature, sunshine and frost data for the Passaic River basin.

Principal Communities and Industries

Approximately 65 percent of the total population is concentrated in the Lower Valley. The principal communities and their 1960 populations are as follows:

Newark - 405,220
Jersey City - 276,101
Paterson - 143,662
Passaic - 53,963
Elizabeth - 107,698
Bayonne - 74,215

TABLE IV - 1

Temperature, Sunshine and Frost Data

(A) Annual Average and Extreme Temperatures

Location	Years of Record	Annual Ave. Temp. °F Max.	Min.	Ave.
Little Falls, N. J.	1914-60	105	-18	52
Entire Passaic Basin	-	108	-26	52
State of New Jersey	-	110	-32	53

(B) Sunshine

Location	Years of Record	Ave. Percent Possible
Passaic Watershed	1895-60	60

(C) Dates of Early and Late Frost

Location	Spring Normal	Latest	Fall Normal	Earliest	Growing Season Days
Highland Area	May 1	June 10	Oct 8	Sept 10	157
Central Basin	April 28	May 25	Oct 15	Sept 21	171
Lower Valley	April 19	May 10	Oct 21	Sept 27	186
Entire Passaic Area	April 26	June 10	Oct 15	Sept 10	171

Source: New York District, U. S. Army Corps of Engineers

Other communities in the area are shown in Figure IV-1.

The Metropolitan area communities centering around the above cities have been extensively developed for both residential and industrial use. Primary industries are chemicals and allied products, fabricated metal products, instruments, paper products, apparel and needle products, machinery, food products and power production.

Industrial development in the Central Basin has centered on the Whippany River where the major industry is paper products. Other significant industries in the area include chemicals, electrical goods and machinery.

Industrial development in the Highlands area has been limited with the majority of the industries locating near the Ramapo River in the vicinity of the New Jersey - New York State line. Principal industries include machinery, paper products and chemicals.

Inventory of Water Uses

A comprehensive inventory of water uses within the Passaic Basin is included in the Appendix, Exhibit I. Significant water uses, including recreation, municipal or industrial water supply, waste disposal, special fire protection, hydraulic power and cooling water are listed with an estimate of present use, treatment and population served.

Important beneficial uses of the basin water not shown on the inventory include: Fishing and boating in the lower portion of the Passaic River below Little Falls, N. J.; and propagation of wildlife in the vicinity of Millington, N. J., on the Passaic River and in the general area of Pompton Lakes on the Ramapo, Wanaque, Pequannock and Pompton Rivers.

III. DESCRIPTION OF PROJECT

Four major plans of development have been proposed by the U. S. Army Corps of Engineers for the Passaic River Basin. These proposals primarily provide flood control for the Passaic River and its tributary streams, but also include other allied uses compatible with this purpose. The four major plans, illustrated by Figures III-1, 2 and 3 are as follows:

a. Reservoir-Tunnel Plan

b. Dry Detention Plan

c. Multipurpose Plan

d. Conservation Plan

a. The Reservoir-Tunnel Plan, with three modifications, consists primarily of a multipurpose reservoir on the Passaic River just upstream of Millington, New Jersey, a flood diversion tunnel in the lower valley from Beatties Dam to Nutley, New Jersey, channel improvements from its mouth to Millington and a flood detention reservoir on the Whippany River just above its confluence with the Rockaway River. The three modifications to this plan include:

1. Flood detention reservoir on the Ramapo River near Oakland, N. J.
2. Flood detention reservoir on the Passaic River at Two Bridges.
3. Conservation pool on the Passaic River at Two Bridges.

The Millington multipurpose reservoir, with a drainage area of 55.4 square miles and a spillway crest elevation of 237 msl (feet above mean sea level) would flood approximately 5,320 acres, primarily the Great Swamp lowlands area, and provide 37,650 acre-feet of storage. The usable storage, though, is 27,200 acre-feet with a dependable safe yield of 635 cfs (41 MGD). The outlet works are located at elevation 218 msl or at a depth of 19 feet below the spillway crest elevation. The outlet works, three conduits with a capacity of 900 cfs (581 MGD), are followed by a stilling basin. The reservoir would be divided into two sections, up to elevation 239 msl, by an earth dike. The upstream portion would be untouched and used for wildlife purposes. The downstream portion would be used for conservation, recreation and flood control purposes. It would be stripped of all organic matter, and stabilized before flooding. Arrangements are provided for an interchange of water between the two pools. The depth of water will average 2.0 to 2.5 feet in the wildlife portion and will vary from a minimum of 5.0 feet in the summer months to an average of 7.0 feet in the conservation portion.

The Two Bridges conservation pool modification would consist of a dam across the Passaic River above the confluence of the Pompton River. Pompton River water would be diverted into the reservoir and Passaic River water would be diverted around the reservoir to Deepavaal Brook which flows into the Passaic River below the dam. The reservoir would provide a total storage of 38,800 acre-feet, a usable storage of 30,000 acre-feet and a dependable yield of 56 MGD. It would flood, primarily, the Great Piece Meadows, a swampy low lying meadowland consisting of a thick mat of organic material.

b. The Dry Detention Plan would consist of a large flood detention reservoir across the Passaic River just above the confluence with the Pompton River and a flood diversion structure on the Pompton River above Lincoln Park to divert flood flows to the detention reservoir. The reservoir has a spillway elevation of 184.25 msl and a maximum flood control storage of 362,400 acre-feet. It will provide no dependable yield or storage. During flood flows this reservoir will inundate the Great Piece Meadows swamp area above Two Bridges, the lowland areas along the Passaic River to Chatham and the lowland areas near the mouths of the Rockaway and Whippany Rivers.

c. The Multipurpose Plan would consist of a multipurpose reservoir across the Passaic River above Two Bridges, a diversion structure on the Pompton River above Lincoln Park, and channel improvements on the lower Passaic River.

The reservoir provides flood control storage of 220,650 acre-feet at elevation 189.4 msl. (By the main dam across the Passaic River.) Conservation storage at elevation 181.0 msl is provided by a levee, constructed from the main dam to a high ridge dividing the watersheds of the Passaic and Rockaway Rivers and the diversion of Pompton River water to the pool. Passaic River water would be diverted around the conservation pool to Deepavaal Brook. The conservation pool would inundate 4,770 acres of marshy swamp area within the Great Piece Meadows under a minimum depth of 4.0 feet of water and provide a dependable storage of 52,000 acre-feet and a dependable yield of 141 cfs (95 MGD). Other pertinent data concerning this plan are shown in Table III-1.

TABLE III-1 Multipurpose Reservoir Plan Data

1.	Conservation Pool Characteristics	
	a. Drainage Area 120 sq mi Passaic) 355.5 sq mi Pompton)	367.5 sq mi
	b. Elevation	181.0 ft msl
	c. Surface area	4,770 acres
	d. Conservation Storage	70,000 acre-ft
	e. Dependable Storage	52,000 acre-ft
	f. Dependable yield	141 cfs (95 MGD)
2.	Spillway Pool Characteristics	
	a. Drainage Area	367.7 sq mi

b. Elevation	189.4
c. Surface area	16,600 acres
d. Flood Control Storage	220,650 acre ft
3. Pompton Diversion	
a. Outlet Works	
Intake Elevation	160.0 ft msl
Total Discharge	
Minimum-Elev 165.0 msl	840 cfs
Maximum-Elev 193.4 msl	3,250 cfs
4. Deepavaal Brook Diversion	
a. Outlet Works	
Intake Elevation	156.0 msl
Total Discharge	
Minimum-Elev 161.0 msl	1,010 msl
Maximum-Elev 193.4 msl	4,350 msl

d. The Conservation Plan includes a dam across the Passaic River above Two Bridges, the previously mentioned Pompton River diversion works and channel improvements below Two Bridges on the Passaic River and on the Pompton River below the diversion works. The reservoir will contain a conservation pool filled by both Passaic and Pompton waters at a normal elevation of 180.0 ft msl and flood storage to a maximum elevation of 203.8 ft msl. The conservation pool would provide a dependable storage of 120,000 acre-feet and a dependable yield of 327 cfs (211 MGD). The reservoir would inundate 13,900 acres at elevation 180 msl. This area is primarily a swamp and marshland consisting of Great Piece Meadows, Trow Meadows, Bogand Village Meadows, Hatfield Swamp and Black Meadows. It is covered with a meadow-mat of variable thickness and accruals of muck and bog material. A large landfill of approximately 80 acres that receives domestic garbage, septic tank pumpage and industrial wastes is located within the reservoir area at elevation 180 ft msl near the confluence of the Whippany and Rockaway Rivers.

Effects of Project on Water Quality

The effects of the four proposed projects on water quality are evaluated separately as follows:

Reservoir-Tunnel Plan

Only Millington Reservoir and the Two Bridges Conservation pool along with channel improvements are expected to affect water quality. However, before presenting an estimate of long-term Millington Reservoir water quality consideration must be given to quality in the Passaic River that will result during the reconstruction of river channels, construction of the Millington Dam and during the period required for stabilization of the impounded water in the Millington Reservoir.

During the construction of this project it is anticipated that cleaning, grubbing and mucking operations will disturb large quantities of clay, sand, and decaying organic material. As a result, poor quality water will occur due to increased concentrations of turbidity, color and BOD. The extent of this water quality degradation will depend largely upon methods of construction employed. All possible efforts should be made to coordinate this work so as to mitigate problems to downstream users.

Following completion of construction, reservoirs require several years for stabilization. During this phase, the quality of water within the impoundment, and thus the quality of augmenting water progressively improves. Disturbed organic matter decays and is stabilized with resultant decreases in color and BOD. Storage results in the settling of suspended solids and turbidity is accordingly reduced.

Ordinarily, a change in regimen from stream to impoundment reduces the point to point reaeration capacity for the given stretch of river. Thus, impoundment results in some reduction in dissolved oxygen concentrations. However, the extensive surface area and relatively shallow depth of the Millington Reservoir should more than offset the loss of run-of-the-river aeration capacity. The combination of shallow depth and large area will also expose greater areas of water surface to sunlight and serve to bleach out natural color. BOD is expected to be lowered by the removal of muck from the Great Swamp and, following impoundment, the BOD of reservoir discharges should be low because of the effects of storage. Insignificant changes in alkalinity and chloride concentrations may occur.

It should be noted that algae and other aquatic plant life may constitute a problem during summer months. Maintaining a minimum depth of five feet during the summer months, as is presently planned, will reduce the problem of weed growths, mosquitoes and other shallow area problems. Further more, an inventory of water use revealed that eutrophication, i.e., fertilization of the water, should be slow since upland sources of nutrients, such as waste effluents and farms with fertilized fields, are rare. The reservoir should be placed under surveillance for algal growths and remedial steps taken as necessary.

Channel improvements will result in an increased velocity and thus a decrease in time of travel between Millington and Newark Bay. Improvements above Little Falls will result in an approximate reduction in time of travel of 18 hours at a flow of 45 cfs between Little Falls and Chatham. Little or no decrease in travel time will result from channel improvements in the tidal portion. The associated increase in velocity will affect water quality

II SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary of Findings

1. Both the scope and depth of this preliminary engineering report in regard to water quality control aspects of the proposed Passaic River Flood Control Project, were restricted because of limitations in time, money and personnel. A more detailed study should be considered before the project enters the advanced stages of engineering design and construction.

2. The U. S. Army Corps of Engineers Passaic River Basin Flood Control Project consists of four alternative reservoirs as follows:

   a. Multipurpose Reservoir at Millington, N. J. with three modification

   b. Dry Flood Detention Reservoir at Two Bridges, N. J.

   c. Multipurpose Reservoir at Two Bridges - partial development.

   d. Multipurpose Reservoir at Two Bridges - full development.

3. The report required two study areas; one for the projection of municipal and industrial water supply and one for the projection of municipal and industrial waste discharges. The two areas were defined as follows:

   a. Municipal and industrial water supply study area was defined on a county basis and consisted of the eight county northern metropolitan district of New Jersey and one county in southeastern New York.

   b. Municipal and industrial waste discharge study area was defined by the hydrological boundaries of the Passaic River Basin.

4. The population of the water supply study area in 1960 was 4,202,000, and the waste discharge study area, 1,544,400 people. Major communities are Newark (405,220), Paterson (143,663), Jersey City (276,101), Elizabeth (107,698), and Bayonne (74,215).

5. Municipal water supplies served 4,093,600 people in 1962 with an average per capita use of 132 gpd, and a total use of 540 MGD.

6. Self-supplied industrial water use in 1962 was estimated to be 315 MGD.

7. Water use in 1962 was estimated at 855 MGD with a dependable yield of 1,305 MGD.

8. Municipal and industrial wastes loads, after treatment, discharged to the Passaic River and its tributaries were estimated to be 16,800 pounds of first stage (5-day) biochemical oxygen demand in 1962. All wastes discharged to the basin receive a minimum of secondary treatment. The major portion of this total load is discharged to the Whippany-Rockaway River, a tributary to the Passaic River.

9. The major discharges of municipal wastes include the City of Morristown and the Rockaway Valley Sewage Treatment Plant. Both provide secondary treatment and discharge an estimated 375 and 1,250 lbs. of BOD/day respectively.

10. The major industrial waste discharge is from the Whippany Paperboard Company. The waste receives a minimum of secondary treatment and contributes an estimated 9,300 lbs. of BOD/day.

11. Water quality in the Whippany River is very poor as it enters the Passaic River. It is highly colored, turbid, has a high nutrient load, high BOD, low DO and high coliform densities. The water is not suitable for municipal or industrial use without very extensive treatments.

12. Water quality of the Rockaway River above Boonton Reservoir is excellent and is used for municipal supplies with a minimum of treatment. Below Boonton Reservoir the quality is generally poor with high BOD's, low DO's, high nutrients and high coliform densities.

13. Waters of the Pequannock, Wanaque, Ramapo, and Pompton Rivers are of

excellent quality and are presently used extensively for municipal and industrial purposes.

14. Passaic River water is good quality above the Whippany-Rockaway River confluence; seriously degraded between the Whippany-Rockaway River confluence and the Pompton River confluence; of suitable quality for municipal and industrial purposes with complete treatment between the Pompton River confluence and tidewater; and brackish and polluted in the tidal portion with high chlorides, total dissolved solids, phenols, BOD's, settleable solids, nutrients, coliform concentrations and low DO's.

Conclusions

1. Population in the municipal and industrial water supply study area is expected to reach 8,800,000 by the year 2020.

2. Population in the municipal and industrial wastes discharge study area is expected to reach 3,200,000 by the year 2020.

3. Municipal water supplies are expected to serve 8,800,000 people a total of 1,365 MGD for an average of 155 gpcd, by the year 2020 and self-supplied industrial water use by year 2020 will be an estimated 565 MGD.

4. Additional storage for water supply purposes is not necessary until the year 1990 assuming present private and state development occurs as planned. In the year 2000 an average need of 70 MGD will exist and in the year 2020 a need of 415 MGD will exist.

5. Municipal and industrial wastes loads, after treatment, discharged to the Passaic River and its tributaries are expected to be approximately 55,300 pounds of first stage (5-day) biochemical oxygen demand by the year 2020. This load will seriously impair water quality in the Passaic River below the confluence of the Whippany-Rockaway River to tidewater, a distance of approximately 33.0 miles.

6. The provision of satisfactory water quality in the Passaic River will protect existing beneficial uses in the form of municipal and industrial water supplies and enhance recreational opportunities in the area above and below Two Bridges, New Jersey.

7. Storage of water is necessary to augment low flows for the maintenance of satisfactory water quality as measured by maintaining a dissolved oxygen content of 4.0 mg/l, 90 percent of the time. The maximum annual draft-on-storage(*) necessary to attain the benefits from improved water quality is 77,000 acre-feet/year at Two Bridges. The necessary storage for the four proposals including losses, to provide the required 77,000 acre-feet/year at Two Bridges is:

a. Reservoir-Tunnel Plan - 85,300
b. Multipurpose Plan - 85,300 acre-feet/year
c. Dry Detention Plan - 85,300 acre-feet/year
d. Comprehensive Plan - No storage required

8. The estimated annual value of the benefits resulting from the provision of the recommended storage for water quality control as based on the cost of providing the same amount of storage by a single purpose reservoir is $390,600 per year. If the entire developed storage for the proposed projects is used for quality control, the following water quality control benefits will result from each proposal:

a. Reservoir-Tunnel Plan - $214,000/year
b. Multipurpose Plan - No value
c. Comprehensive Plan - $355,850/year
d. Dry Detention Plan - No value

(*) Annual draft-on-storage is defined as the sum of incremental excesses of needed releases over inflows during a climatic year.

9. The annual value of benefits for providing water supply storage of 415 MGD is $2,846,580. This was computed on the basis of a least cost alternate which was a single purpose reservoir on the Passaic River at the Two Bridges site supplemented by waste-water reuse. The year of first need is 1990 and the benefits were discounted from 1960.

Recommendations

1. Consideration should be given to stripping and stabilizing the bottoms of all storage reservoirs constructed in the Two Bridges Great Piece Meadows area.

2. Consideration should be given to possible contamination from the landfill located within the Two Bridges reservoir site. It is recommended that this landfill be well diked and isolated from the reservoir.

3. Multi-level outlets are recommended for all storage reservoirs with quality control programs to insure the use of the best quality waters for release.

4. Care should be exercised in the interchange of waters between the wildlife portion and conservation portion of the Millington Reservoir in the Reservoir-Tunnel Plan.

LIST OF EXHIBITS

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V-3 Water Quality Station Locations

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VI-1 Population Trends

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I. INTRODUCTION

Request and Authority

By a letter dated September 30, 1964 the New York District of the U. S. Army Corps of Engineers requested the Public Health Service to proceed with a study and report on water quality and water use aspects of the several plans of development for the proposed Passaic River Basin flood control plan.

This study was made under the provisions of (1) the Memorandum of Agreement, dated November 7, 1961 between the Department of Army and the Department of Health, Education, and Welfare relative to Title III of P.L. 500, 85th Congress as amended by P.L. 87-88 and (2) the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.).

Purpose and Scope

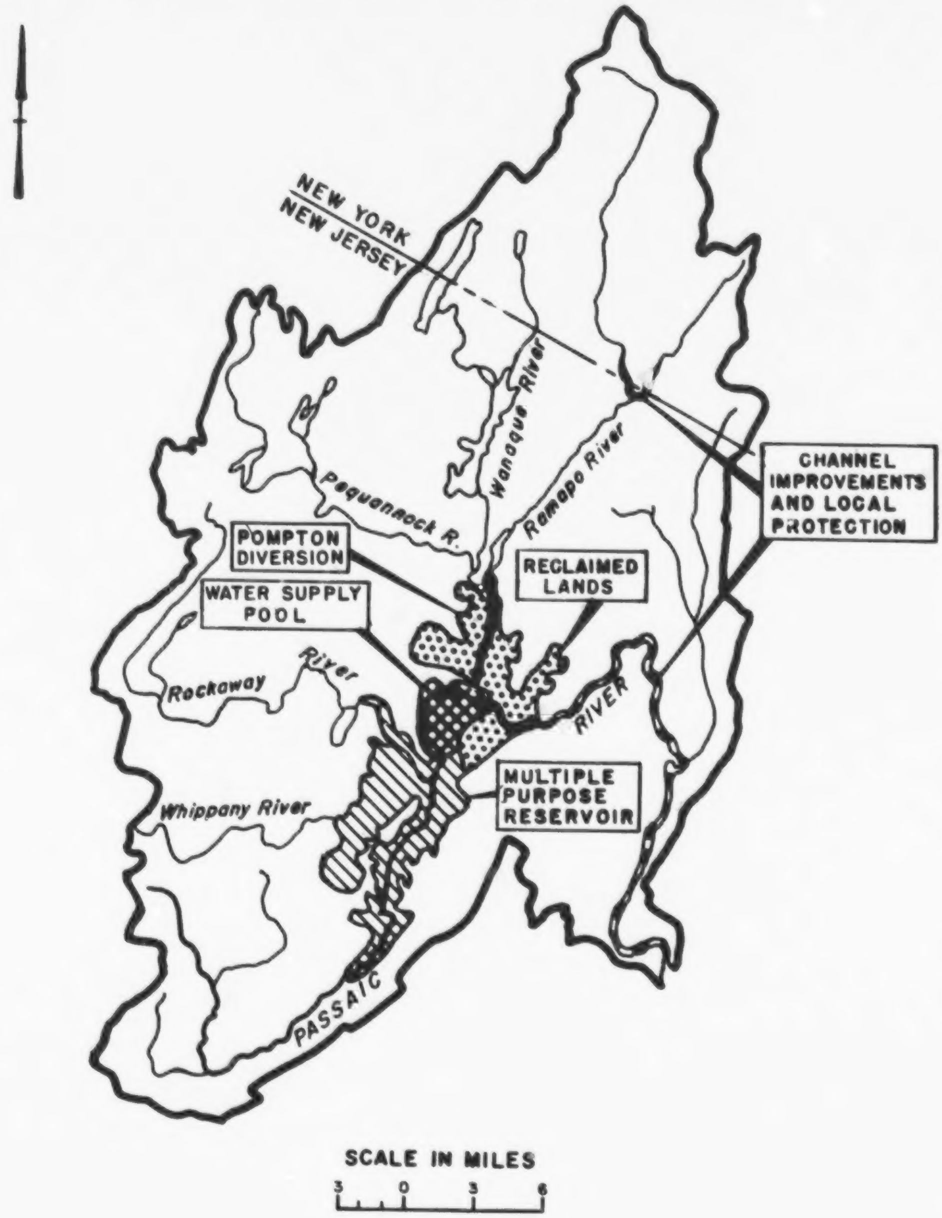
The purpose of this study is to determine the need for and value of storage for municipal and industrial water supply, and flow regulation for water quality control in the Passaic River Basin through the year 2020. Because of time, money and personnel restrictions, however, this report is limited in its depth of coverage and may be subject to revision upon more extensive study.

Acknowledgements

This study was made possible through the assistance of the following Federal, State and local agencies:

1. U. S. Army Corps of Engineers, New York District
2. U. S. Department of Interior, Geological Survey
3. State of New Jersey, Division of Water Policy and Supply
4. State of New Jersey, Department of Health
5. State of New Jersey, Department of Conservation and Economic Development
6. Morris County Planning Board
7. Passaic Valley Water Commission
8. Passaic Valley Sewerage Commissioners
9. North Jersey District Water Supply Commission
10. City of Newark, Division of Water Supply
11. City of Jersey City, Division of Water
12. Hackensack Water Company

PASSAIC RIVER, BASIN PLAN OF DEVELOPMENT



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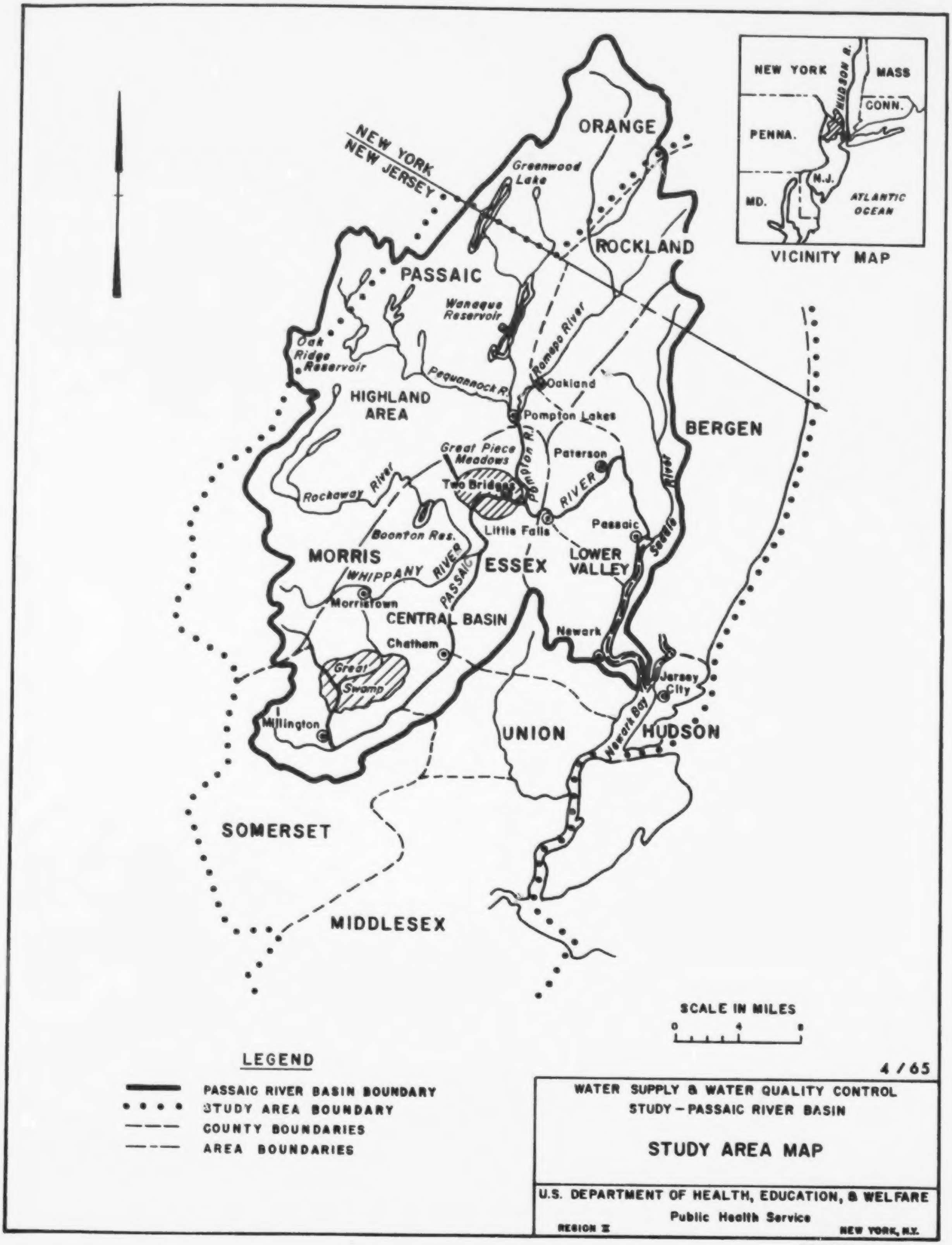
WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

MULTIPLE-PURPOSE
RESERVOIR PLAN

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service
REGION II
NEW YORK, N.Y.

FIGURE III-3



WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

STUDY AREA MAP

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service
REGION II NEW YORK, N.Y.

FIGURE IV-1

XI. APPENDICES

EXHIBIT I: Inventory of Water Use

EXHIBIT II: Minimum Standards Adopted by the Passaic Valley Water Commission

EXHIBIT III: Computations For Municipal and Industrial Water Supply Benefits

EXHIBIT IV: Storage For Water Quality Control Benefit Calculations

EXHIBIT I

PASSAIC RIVER INVENTORY OF WATER USES
EXPLANATION OF CODE

RIVERS (Column 2)

B - Black Brook
C - Canoe Brook
De - Dead River
D - Deepavaal Brook
M - Mahwah
Pa - Packanack Brook
P - Passaic
Pec - Peckman
Pe - Pequannock
Po - Pompton
Ra - Ramapo
Ro - Rockaway
S - Singac Brook
Wa - Wanaque
W - Whippany

USE (Column 3)

CW - Industrial cooling water
SD - Sewage disposal
IWS - Industrial water supply
MWS - Municipal water supply
RP - Recreation, park
HP - Hydraulic Power
FP - Special fire protection

WATER TREATMENT (Column 6)

Cl - Chlorine disinfecting
C - Coagulation by chemicals
S - Sedimentation
SSF - Slow sand filters
RSF - Rapid sand filters
Misc - Miscellaneous
PSF - Pressure sand filter

WASTE TREATMENT (Column 6)

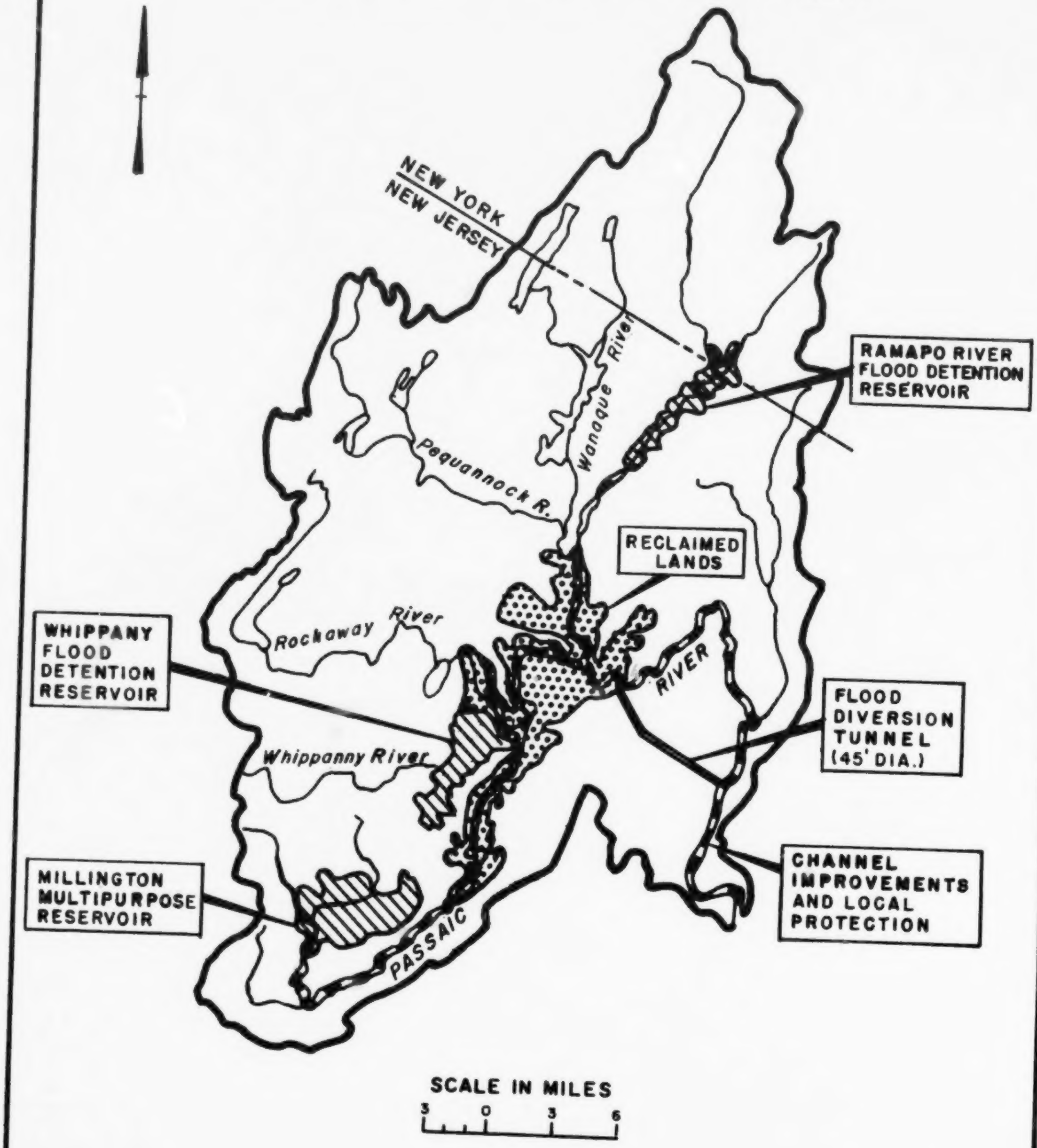
S - Sedimentation
Cl - Chlorine disinfecting
TF - Trickling filters
L - Lagoons
AS - Activated sludge
SF - Sand filters

PASSAIC RIVER -- WATER USE INVENTORY (EX. I Cont.)

Name PASSAIC RIVER	River Mile	Use	Population Served In Thousands	Flow MGD	Treatment
Power Plant	P 2.0	CW	-	370	-
River Bank Park	P 4.8	RP	-	-	-
Saddle River	P 15.6	Tributary			
Pulaski Park	P 15.9	RP	-	-	-
Dundee Dam (Dundee Water and Power Co)	P 17.4	IWS	-	-	-
Whippany Paperboard Co.	P 17.4	IWS	-	4.3	NONE
Garden State Paper Co.	P 17.5	IWS	-	8.0	Misc
C.S. Fields Co.	P 17.5	FP	-	-	-
E. Paterson Twp.	P 18.4	SD	3.3	0.9	TF, Cl
Marcal Paper Products Co.	P 19.0	IWS, FP	-	8.0	Cl,C,S,SSF
East Side Park	P 19.7	RP	-	-	-
Interchemical Corp.	P 24.7	IWS,CW	-	0.85	C,PSF
Public Service Gas Co.	P 25.0	CW	-	8.0	-
S.U.M. Dam	P 25.4	HP	-	-	-
West Side Park	P 25.6	RP	-	-	-
Boro of Totowa	P 27.3	SD	7	0.7	TF,Cl
Boro of W. Paterson	P27.4	SD	-	0.5	Cl,TF
Peckman River	P28.2	Tributary			
Passaic Valley Water Commission	P 29.6	MWS	500	42	Cl,C,S,RSF
Beatties Dam	P 29.6	HP	-	-	-

Name	River Mile	Use	Population Served In Thousands	Flow MGD	Treatment
PASSAIC RIVER					
North Jersey Training School	P 30.6	SD	1.3	0.1	TF,Cl,SF
Singac Brook	P 31.9	Tributary			
Deepavaal Brook	P 32.2	Tributary			
Pompton River	P 33.0	Tributary			
Whippany River	P 45.8	Tributary			
Caldwell Township	P 46.2	SD	17	1.8	TF,Cl
Foulertons Brook	P 47.7	Tributary			
Livingston Twp Main Plant	P 49.0	SD	22	1.5	AS,Cl
Livingston Twp Okner Pkwy	P 50.2	SD	1	.05	SF,Cl
Canoe Brook	P 56.0	Tributary			
Commonwealth Water Co.	P 56.0	MWS	-	7.5 (Varies)	-
Madison-Chatham Joint Meeting	P 56.4	SD	28	1.6	AS,Cl
New Providence Twp	P 60.7	SD	2	-	Storm Water Overflow, above 1.12MGD-S,Cl
Berkeley Heights	P 63.8	SD	10	.75	TF,Cl
Passaic Township	P 67.7	SD	1.2	.12	TF,Cl
Dead River	P 70.5	Tributary			
U. S. Gypsum Co.	P 73.2	SD	-	0.9	S,L
U. S. Gypsum Co.	P 73.3	IWS	-	1.0	NONE
Bernardsville	P 78.3	MWS	15E	2.0E	C,S,RSF,Cl
		Saddle River			
Boro of Fair Lawn	Sa 7.5	SD	24	2.5	TF,Cl
Boro of Ridgewood	Sa 8.0-1.0	SD	17.5	1.8	S,Cl

PASSAIC RIVER, BASIN PLAN OF DEVELOPMENT


NEW YORK
NEW JERSEY
Wanaque River
Pequannock R.
Rockaway River
Whippany River
PASSAIC
RIVER
RAMAPO RIVER FLOOD DETENTION RESERVOIR
RECLAIMED LANDS
WHIPPANY FLOOD DETENTION RESERVOIR
FLOOD DIVERSION TUNNEL (45' DIA.)
MILLINGTON MULTIPURPOSE RESERVOIR
CHANNEL IMPROVEMENTS AND LOCAL PROTECTION
SCALE IN MILES
3
0
3
6

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY — PASSAIC RIVER BASIN

COMPREHENSIVE RESERVOIR
TUNNEL PLAN

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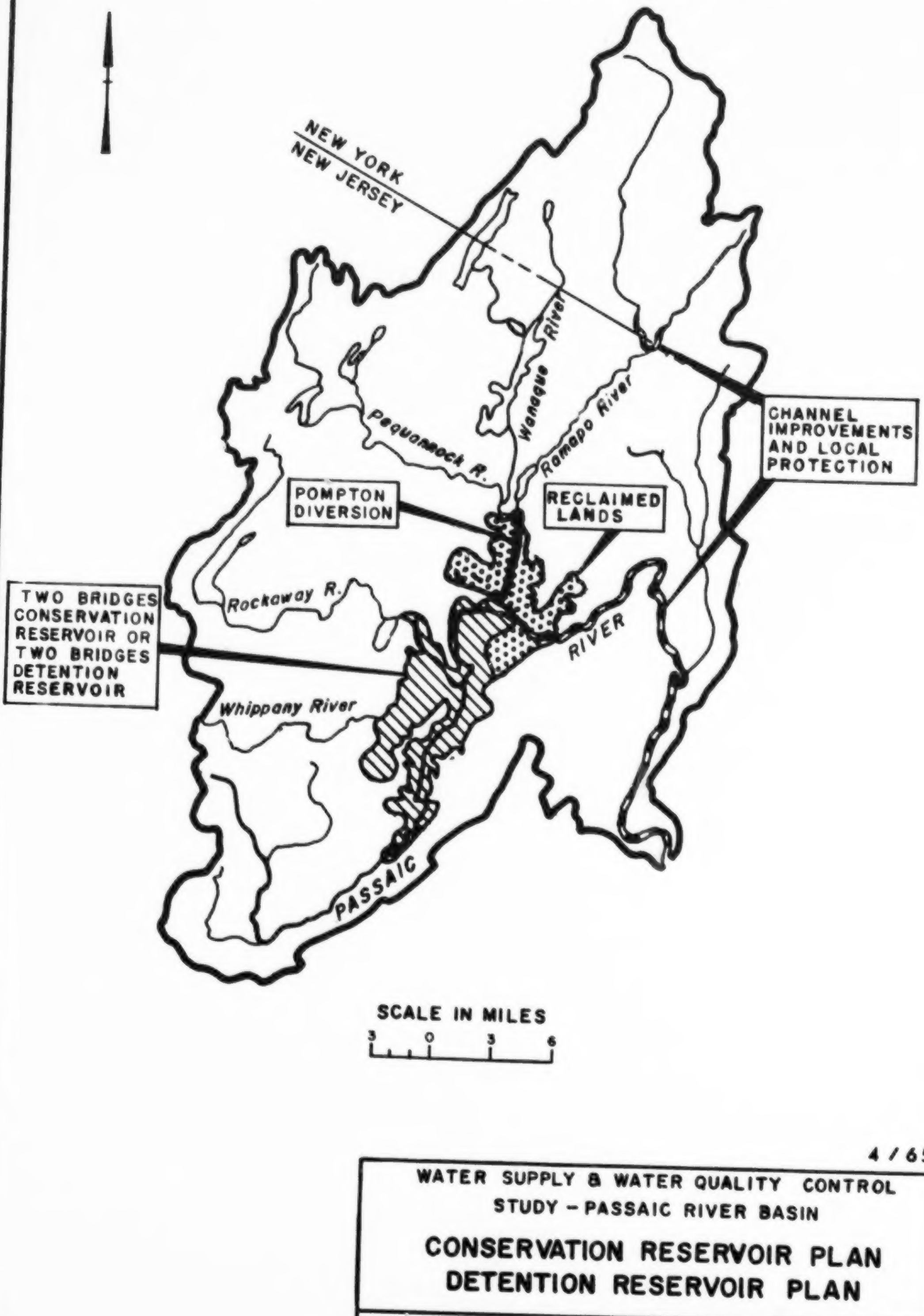
FIGURE III-1

PASSAIC RIVER, BASIN PLAN OF DEVELOPMENT



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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

CONSERVATION RESERVOIR PLAN
DETENTION RESERVOIR PLAN

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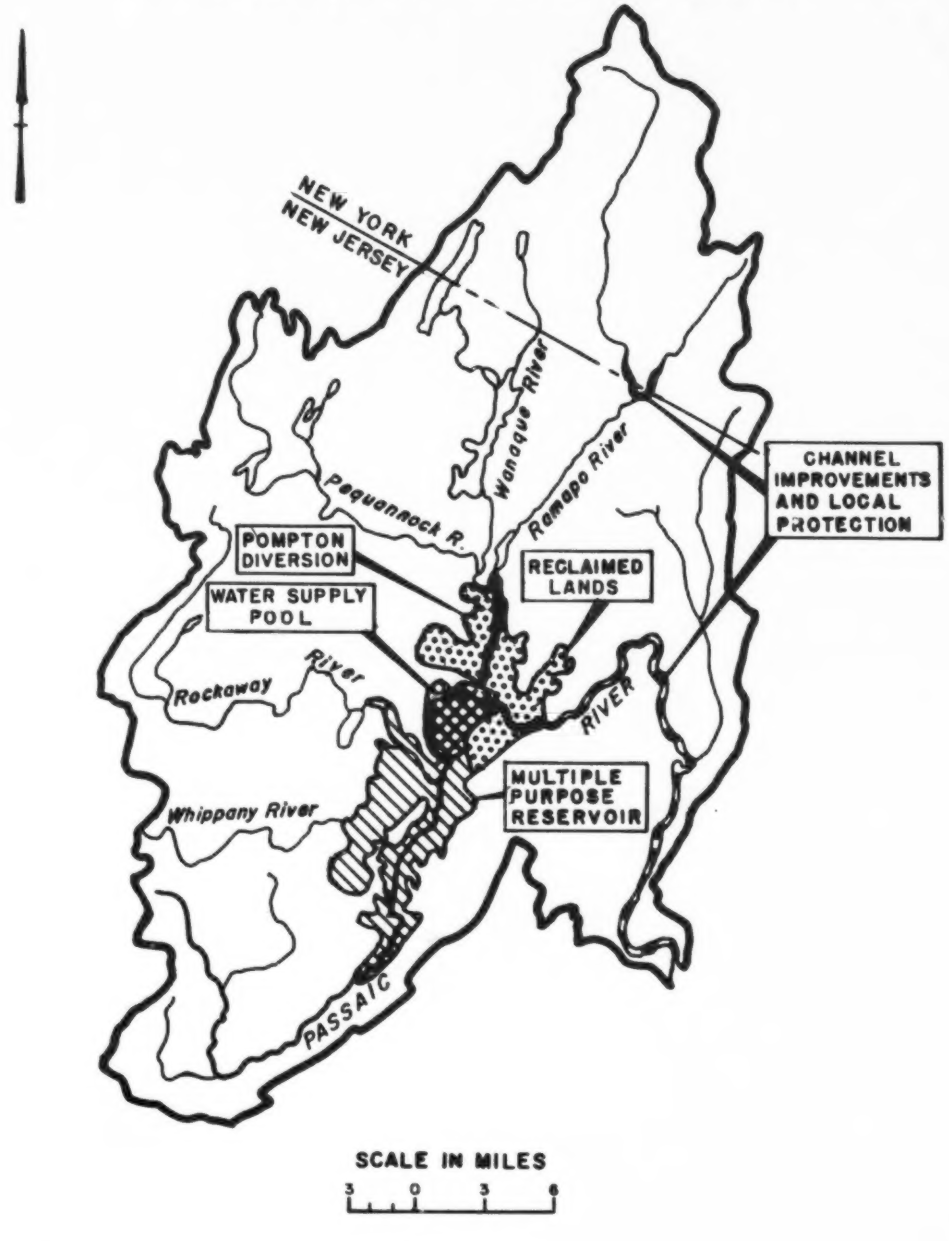
FIGURE III - 2

PASSAIC RIVER, BASIN PLAN OF DEVELOPMENT



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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

MULTIPLE-PURPOSE
RESERVOIR PLAN

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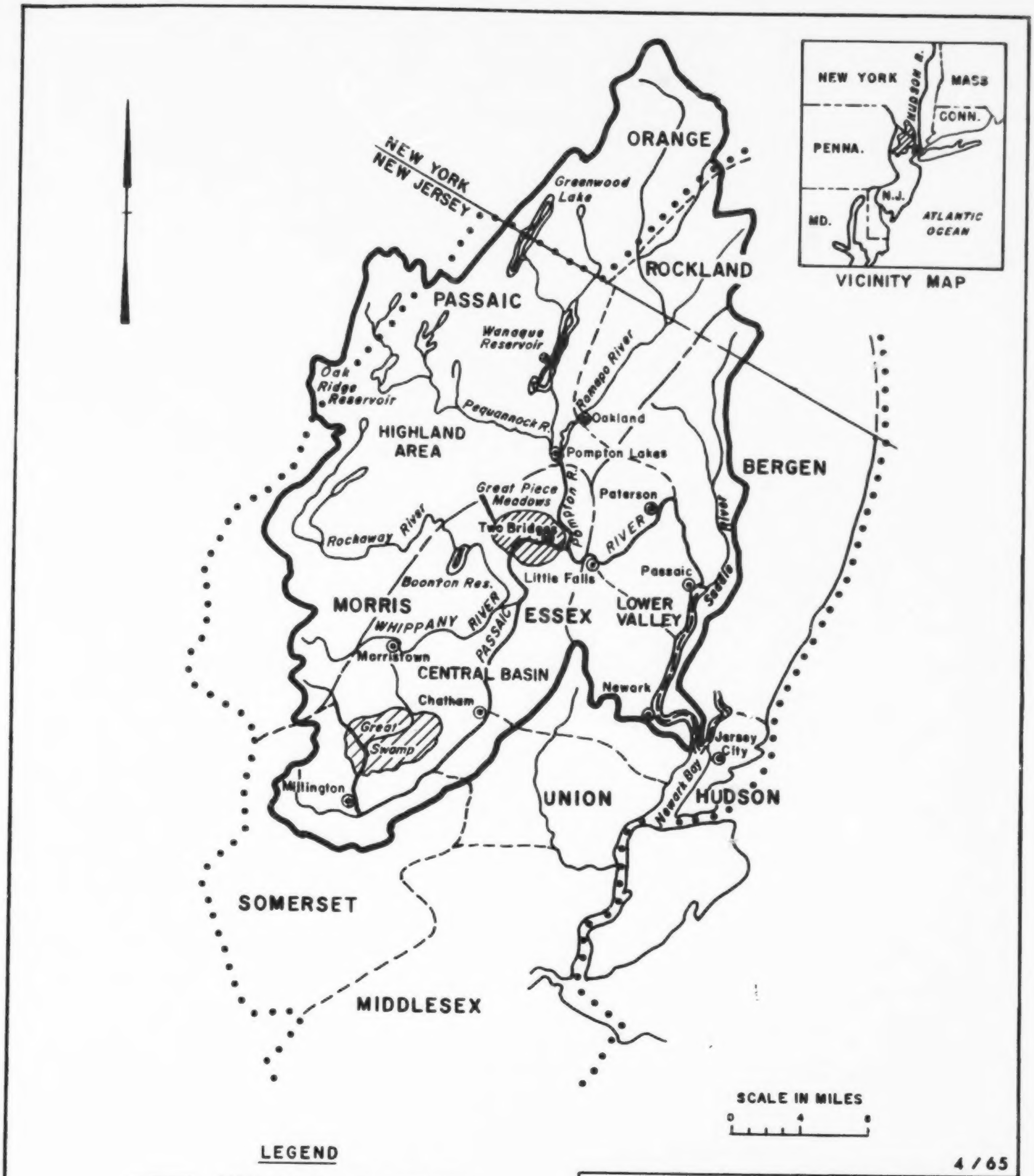
FIGURE III-3



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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

STUDY AREA MAP

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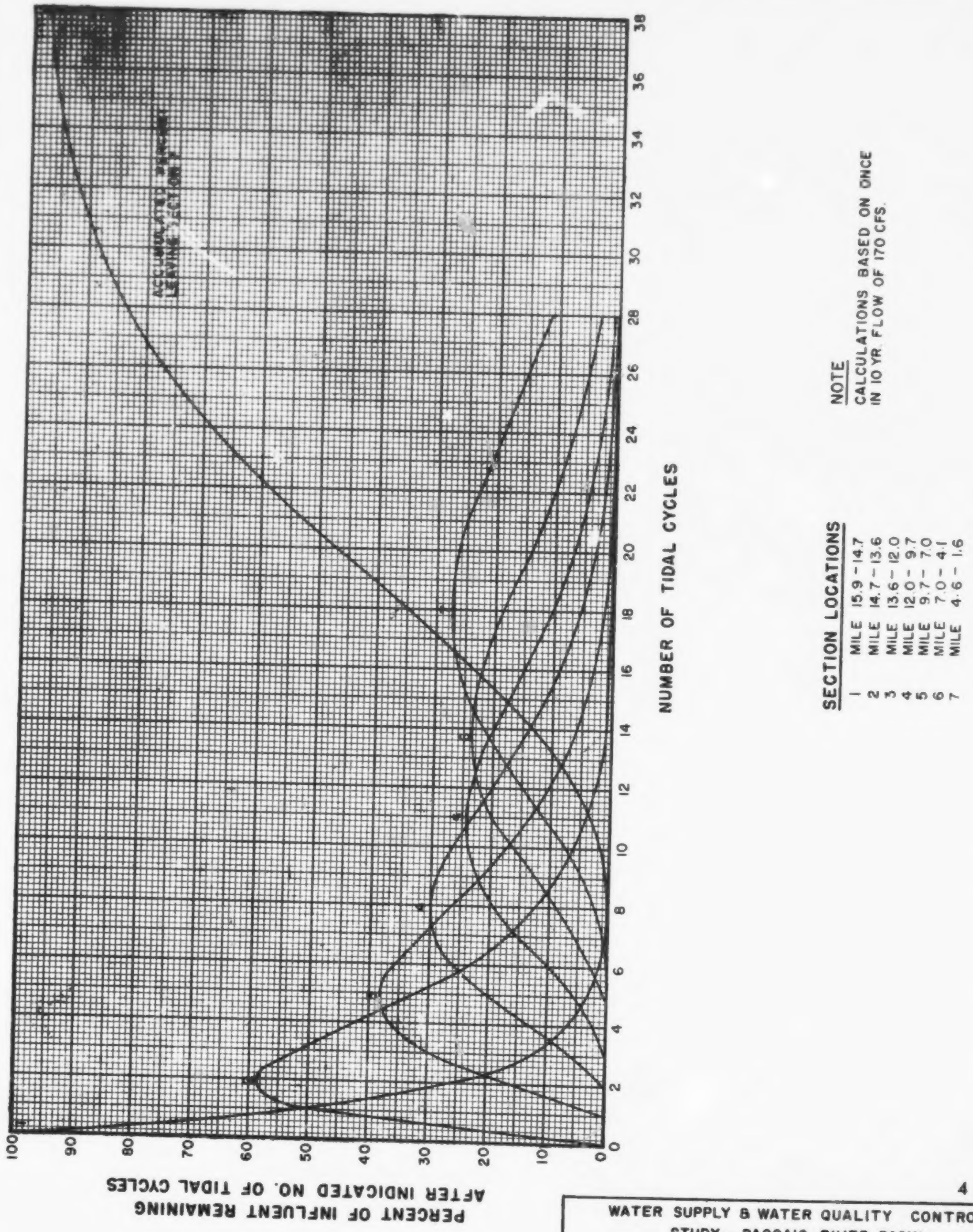
FIGURE IV-1



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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

DETENTION TIME IN TIDAL
PORTION OF PASSAIC RIVER

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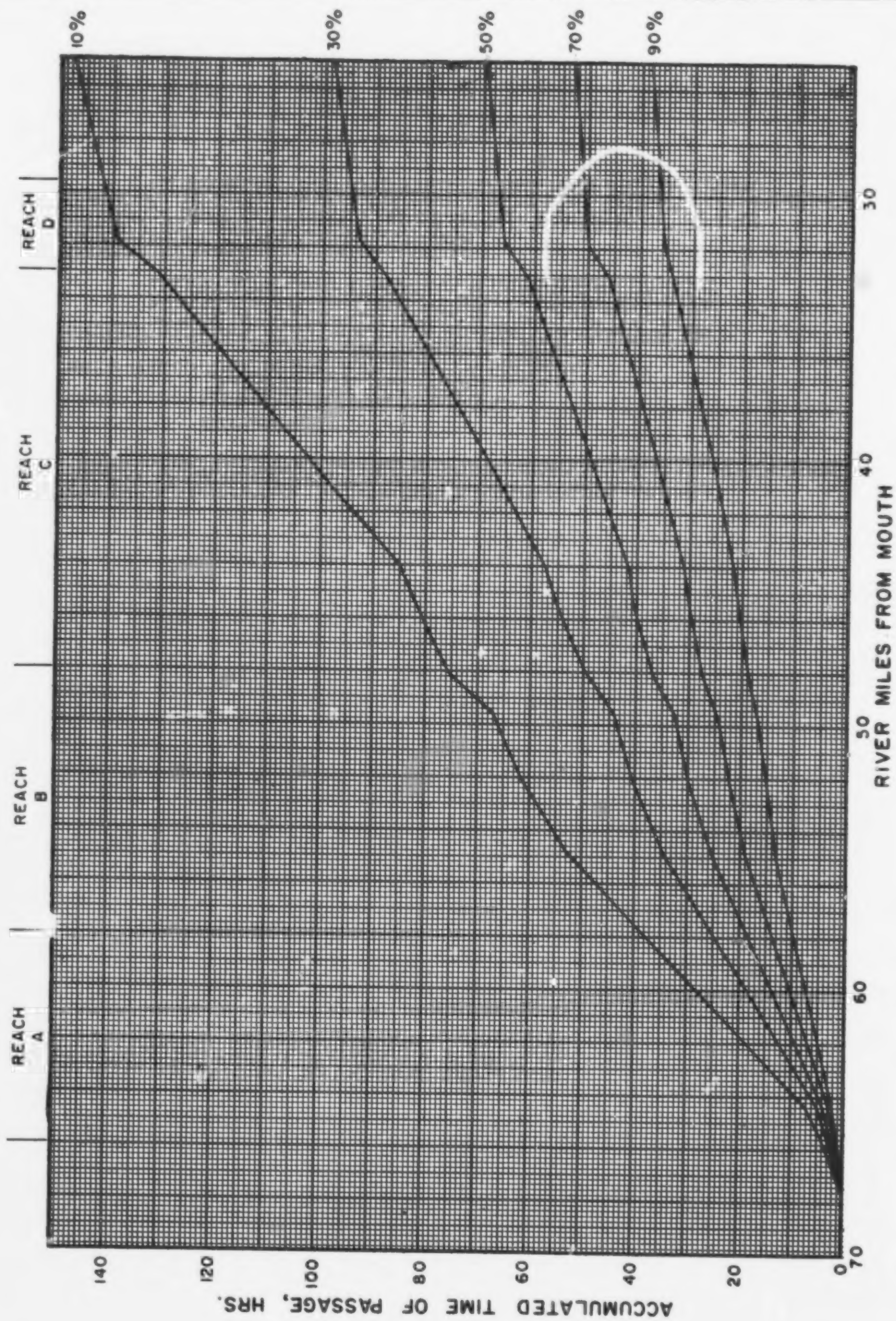
FIGURE V - 1



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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

ACCUMULATED TIME OF FLOW OF PASSAIC RIVER FOR SEVERAL PROBABILITY LEVELS

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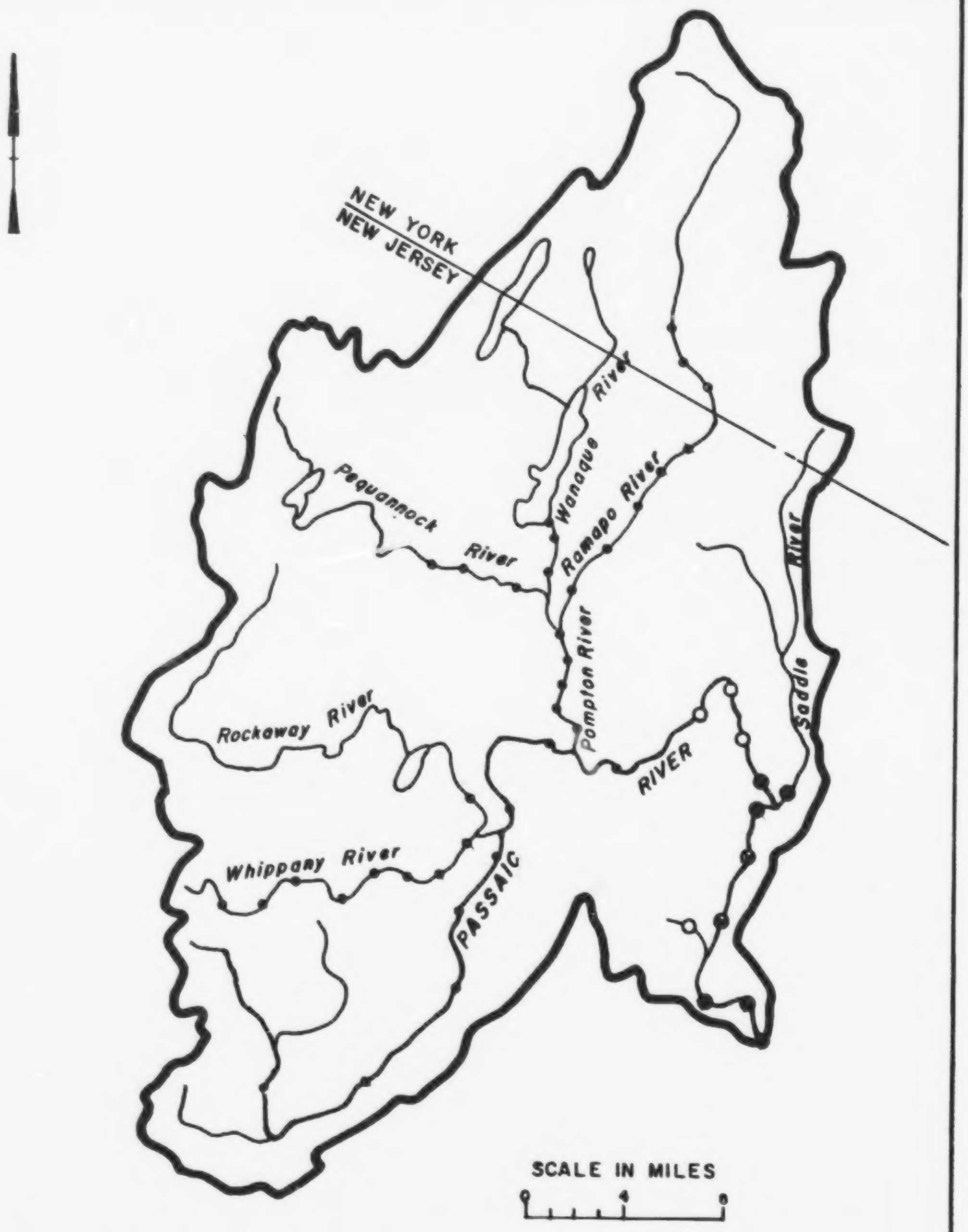
FIGURE V-2



LEGEND

- • PASSAIC VALLEY WATER COMMISSION (PVWC) STATIONS.
- ○ PASSAIC VALLEY SEWERAGE COMMISSION (PVSC) STATIONS.
- ● COMBINED PVSC AND USPHS SAMPLING STATIONS.

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY—PASSAIC RIVER BASIN

WATER QUALITY STATION LOCATIONS

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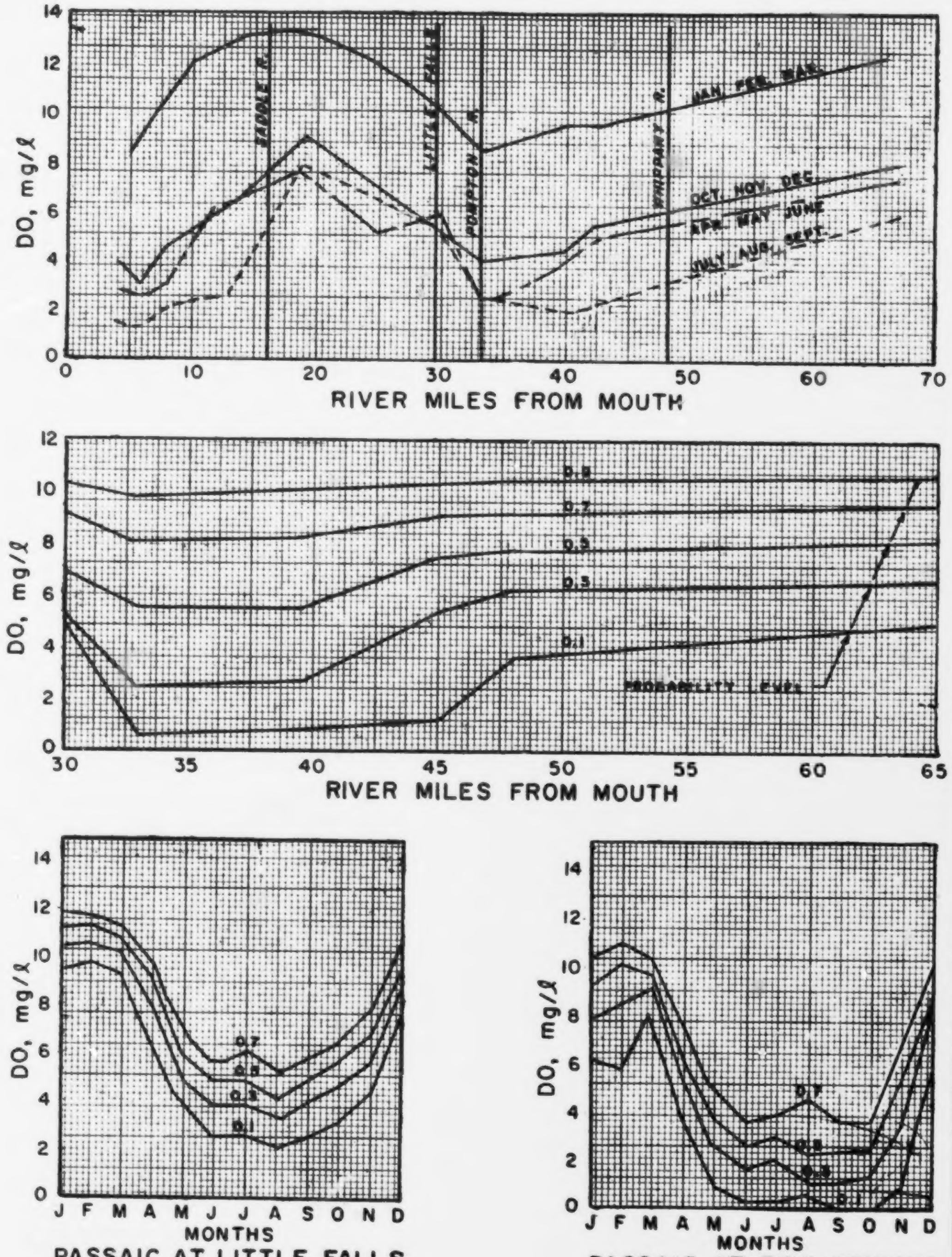
FIGURE V -3



PASSAIC AT LITTLE FALLS

PASSAIC AT TWO BRIDGES

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

SEASONAL, MONTHLY AND PROBABILITY
LEVEL DO VARIATION

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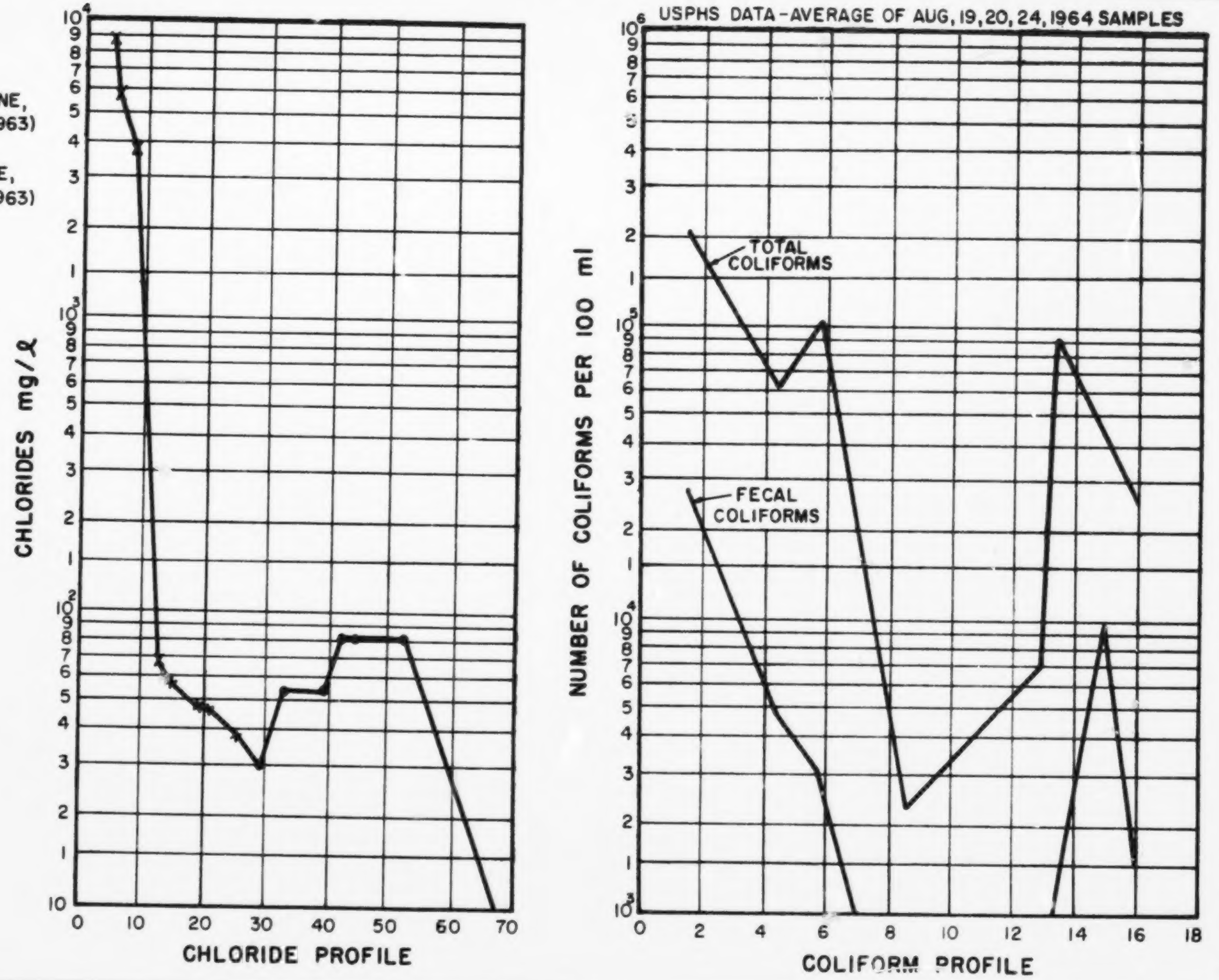
FIGURE V-4



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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

WATER QUALITY PROFILES

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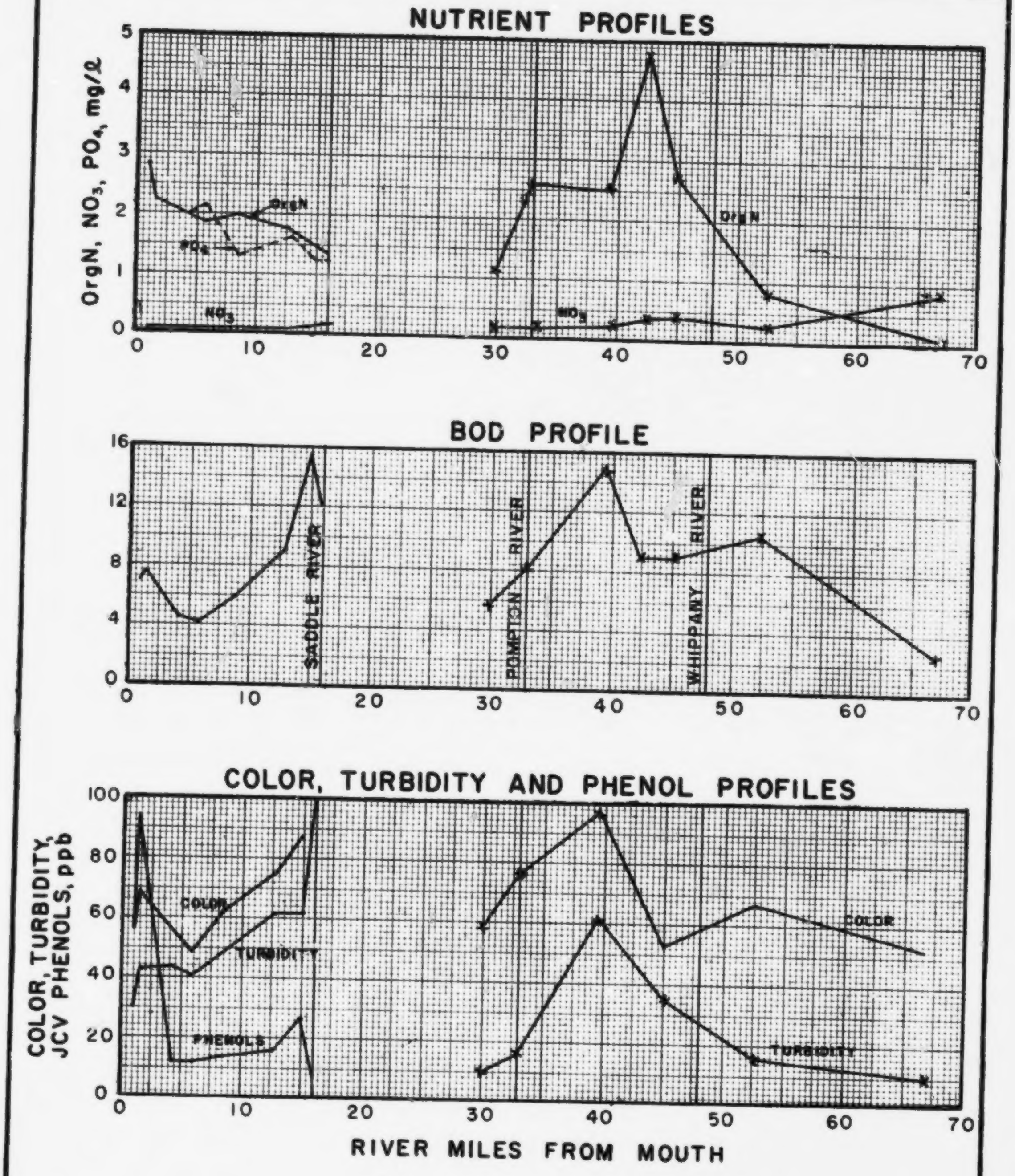
FIGURE V-5



LEGEND

- • USPHS DATA – AVERAGE OF AUG. 19,20,24, 1964 SAMPLES
- X PVWC DATA – AVERAGE OF 5 SAMPLES TAKEN JUNE, JULY, AUG, SEPT, OCT. 1963

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

PASSAIC RIVER
WATER QUALITY
PROFILES

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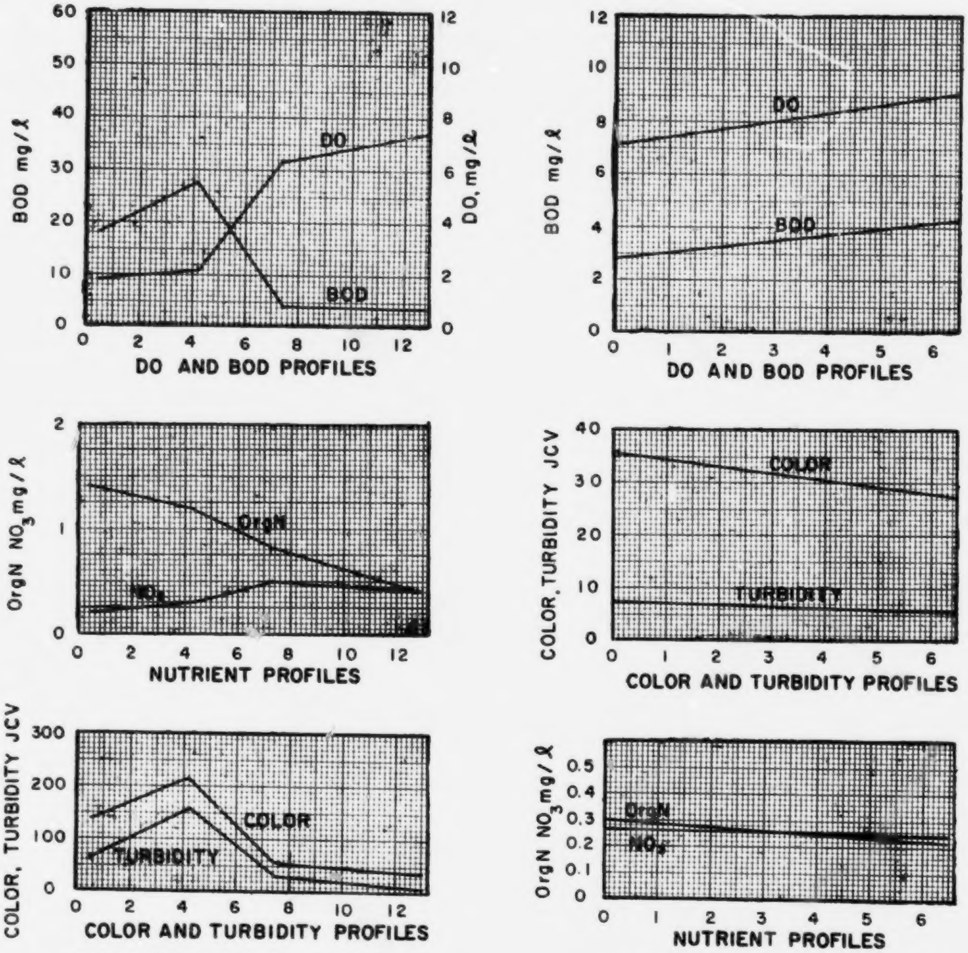
FIGURE V-6



DO AND BOD PROFILES

DO AND BOD PROFILES

NUTRIENT PROFILES

COLOR AND TURBIDITY PROFILES

COLOR AND TURBIDITY PROFILES

NUTRIENT PROFILES

WHIPPANY RIVER PROFILES

POMPTON RIVER PROFILES

NOTE:
ALL DATA FURNISHED BY PVWC
IS THE AVERAGE OF 5 SAMPLES
TAKEN IN JUNE, JULY, AUG, SEPT,
OCT. 1963

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY—PASSAIC RIVER BASIN

POMPTON AND WHIPPANY RIVER
WATER QUALITY
PROFILES

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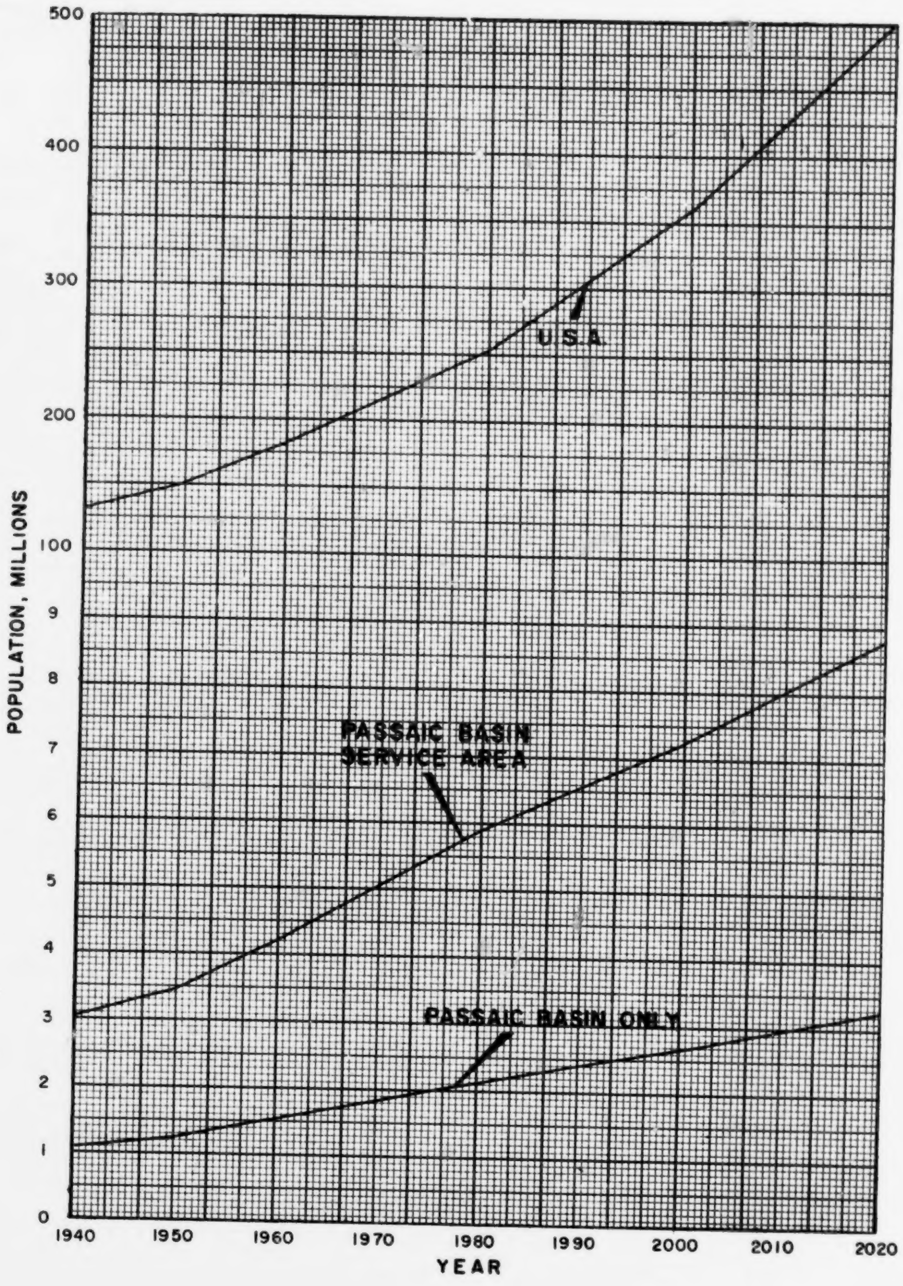
FIGURE V-7



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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

POPULATION TRENDS

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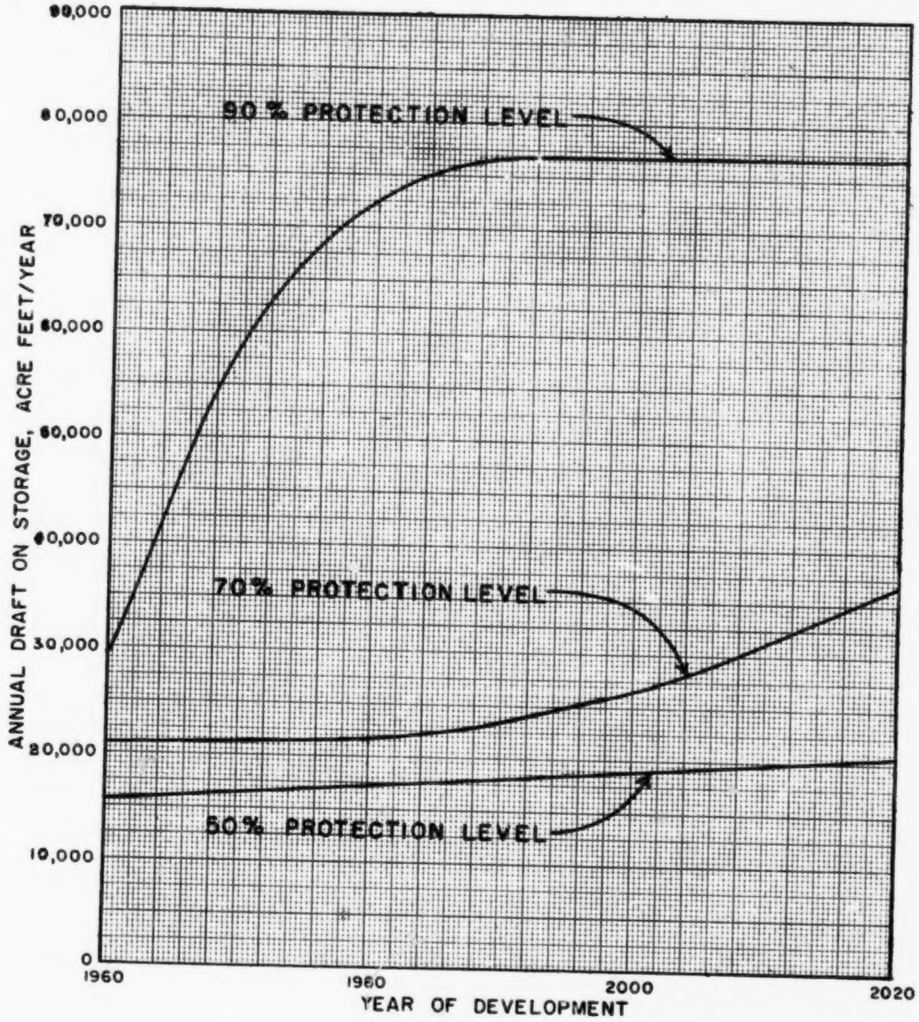
FIGURE VI-1



REQUIREMENTS FOR VARIOUS LEVELS
OF PROTECTION AT LITTLE FALLS

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WATER SUPPLY & WATER QUALITY CONTROL
STUDY – PASSAIC RIVER BASIN

WATER QUALITY
MAINTENANCE STORAGE

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FIGURE VII-1